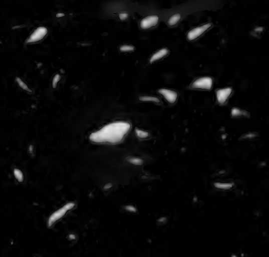
H.P. Msanga

SEED GERMINATION OF INDIGENOUS TREES IN TANZANIA

Including Notes on Seed Processing, Storage and Plant Uses



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The Canadian Forest Service's Northern Forestry Centre is responsible for fulfilling the federal role in forestry research and technology transfer in Alberta, Saskatchewan, Manitoba, and the Northwest Territories. The main objectives are research in support of improved forest management for the economic, social, and environmental benefit of all Canadians.

The Northern Forestry Centre, as the Canadian Executing Agency for the Southern African Development Community Tree Seed Centre Network (SADC TSCN), has undertaken publication of this book in the belief that it will support improved forest management at an international level. The SADC TSCN project was funded by the Canadian International Development Agency (CIDA).

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Le Service canadien des forêts, Centre de foresterie du Nord, représente le gouvernement fédéral en Alberta, en Saskatchewan, au Manitoba et dans les Territoires du Nord-Ouest en ce qui a trait aux recherches forestières, et au transfert de technologie. Cet organisme s'intéresse surtout à la recherche en vue d'améliorer l'aménagement forestier afin que tous les Canadiens puissent en profiter aux points de vue économique, social et environnemental.

À titre d'Agent exécutif canadien du Réseau du Centre des semences d'arbres de la Communauté pour le développement de l'Afrique australe (SADC TSCN), le Centre de foresterie du Nord a entrepris la publication de ce livre dans l'espoir qu'il favorisera l'aménagement des forêts à l'échelle internationale. Le projet du SADC TSCN est financé par l'Agence canadienne de développement international.

Le Centre de foresterie du Nord constitue l'un des cinq établissements du Service canadien des forêts, dont l'administration centrale est à Ottawa (Ontario).

Cover:

Pterocarpus angolensis **seeds.**

100-06342/

SEED GERMINATION OF INDIGENOUS TREES IN TANZANIA

Including notes on seed processing
and storage, and plant uses

Heriel Petro Msanga

Canadian Forest Service
Northern Forestry Centre
1998

© H.P. Msanga, 1998
Catalogue No. Fo42-282/1998E
ISBN 0-660-17707-2

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Published by:

Canadian Forest Service
Northern Forestry Centre
5320 – 122 Street
Edmonton, Alberta T6H 3S5

This publication can be purchased from:

UBC Press
University of British Columbia
6344 Memorial Road
Vancouver, British Columbia V6T 1Z2
Phone (604) 822-5959
Fax 1-800-668-0821

UBCPress

Canadian Cataloguing in Publication Data

Msanga, Heriel Petro, 1952–

Seed germination of indigenous trees in Tanzania : including notes on seed processing, storage and plant uses

Includes an abstract in French.
Includes bibliographical references and an index.
ISBN 0-660-17707-2
Cat. No. Fo42-282/1998E

1. Tree crops -- Propagation -- Tanzania. 2. Trees -- Propagation -- Tanzania. 3. Tree crops -- Tanzania -- Seeds. 4. Trees -- Tanzania -- Seeds. 5. Germination. 6. Medicinal plants -- Tanzania. I. Northern Forestry Centre (Canada). II. Title.

SB171.T36M72 1998 634.9562'09678 C99-980041-8

Msanga, H.P. 1998. *Seed germination of indigenous trees in Tanzania*. Nat. Resour. Can., Can. For. Serv., North. For. Cent., Edmonton, Alberta.

ABSTRACT

Fruit and seed characteristics are described for 123 species of trees found in Tanzania. Methods of seed extraction and storage are detailed, and recommended pretreatments are identified. Descriptions of the germination process are accompanied by drawings of germination stages for each species. Colour photographs of fruit or seed of eighteen species are included.

The most common seed pretreatment methods are described and explained in an introductory section, as are various germination and rapid viability tests. Methods for growing tree seedlings from seed are presented.

English, Kiswahili, and vernacular species names are listed with scientific equivalents. A glossary of technical terms, a table summarising seed characteristics and requirements for each species, a list of references, and a general index are included.

RÉSUMÉ

On décrit les caractéristiques des fruits et des graines de 123 essences de la Tanzanie. On présente des techniques d'extraction et d'entreposage des semences ainsi que les prétraitements recommandés. Les descriptions du processus de germination sont accompagnées de dessins des stades de germination pour chaque essence. On présente aussi des photographies en couleurs des fruits ou des graines de 18 espèces.

On décrit et explique dans l'introduction les techniques les plus courantes de prétraitement des semences, de même que divers tests de germination et tests rapides de viabilité. On présente des méthodes de culture de semis à partir des semences.

On donne les noms anglais, swahilis et vernaculaires des essences, de même que leur nom scientifique. On présente aussi un glossaire des termes techniques, un tableau des caractéristiques des semences et des exigences de chaque essence, un bibliographie et un index général.

MEDICINAL WARNING

The traditional and therapeutic uses and medicinal values of plants described here are given for informational purposes only. Medicinal use of plants should be carried out only under the care of a qualified health care professional. Please note that some plants included in this book are poisonous, and others may cause adverse reactions in some individuals.

FOREWORD

This book contains five sections: 1. Introduction; 2. Seed presowing treatments; 3. Germination and rapid viability testing; 4. Methods for large scale germination; and 5. Fruit and seed characteristics of individual tree species. The main text, Section 5, is a compilation of original information on germination characteristics of seeds of 123 tree species of Tanzania, and the uses of these trees. The information is presented in simple form, and describes practices recommended where local experience in handling seeds of indigenous tree species is limited or lacking.

In the main text both genus and species names of the trees are arranged in alphabetical sequence. The text includes: common and vernacular names (Tanzanian), fruit morphology and seed extraction methods, seed morphology, seed presowing treatments, seed germination characteristics, line drawings to illustrate stages in seed germination behaviour, and plant uses.

About 140 line drawings which illustrate this book were made by the author from his own specimens. He has included them in the belief that a drawing is worth a thousand words. They seek to convey impressions, and do not pretend to be accurate in every detail.

The trees included are those of known economic importance or which have particular attributes that suggest potential for future importance. These species were studied by the author during his private time at various stages of higher learning and research work while he was serving as a research officer with the Forest Department at the Silvicultural Research Station, Lushoto (1979–1990), as head of the Seed Research Section (1990–1996), and later as programme manager of the National Tree Seed Programme, both at Morogoro (1996–present). Any shortcomings in this book are, therefore, entirely his own responsibility.

I hope that this book will be of use to foresters, forestry students, farmers and people who are involved in tree seed production and marketing in Tanzania and elsewhere in the tropics where similar species are planted. It may also be useful to people involved in tree planting and use.

Professor Said Iddi
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Dedicated to

my wife Teresia

for her encouragement in writing this book.

ACKNOWLEDGEMENTS

I am indebted to Dr. Sally E.T. John, former technical advisor, Southern African Development Community (SADC) Tree Seed Centre Network (TSCN), Harare, Zimbabwe, for correcting the English and making useful technical comments at various stages of compiling material for this book. I wish to thank Prof. Jumanne A. Maghembe, Principal Scientist, International Centre for Research in Agroforestry (ICRAF), Zomba, Malawi and Mr. Ben S.P. Wang, Scientist Emeritus, Petawawa National Forestry Institute, Canada, for reading the manuscript and giving guidance. I cannot forget the assistance of Mr. Christopher Ruffo, botanist of the National Tree Seed Programme (NTSP), Morogoro, Tanzania, for providing Tanzanian names of trees and checking scientific names.

I also wish to thank the scientific and editorial review committee, comprising Dr. S.E.T. John (chair), Isabella Point Forestry Ltd., Salt Spring Island, B.C., Canada; Dr. D. Khasa, Department of Renewable Resources, University of Alberta, Canada; Dr. D. Kolotelo, B.C. Ministry of Forests, Canada; Dr. Marzalina M., Senior Research Scientist, Forest Research Institute of Malaysia, Kuala Lumpur, Malaysia; and Mr. B.S.P. Wang, Scientist Emeritus, Petawawa National Forestry Institute, Canada, for their thorough review and many helpful comments and suggestions for improving the utility of the manuscript. I am also grateful to Dr. J.S. Brouard, Isabella Point Forestry Ltd., Salt Spring Island, B.C., Canada, and Dr. P.K. Ades, School of Forestry, University of Melbourne, Australia, for their less formal but thorough review. Dr. John worked closely with me to incorporate changes to the manuscript.

Any errors contained herein, however, remain my responsibility.

Ms. B. Laishley, Natural Resources Canada, Edmonton, Canada, facilitated publication of this book, and smoothed its journey to completion.

I acknowledge with thanks the financial support of the Canadian International Development Agency (CIDA) through Natural Resources Canada and the SADC TSCN, which made the publication of this book possible. With their assistance, the cost of this book has been kept low, so that it can benefit many people.

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July 1998

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Heriel Petro Msanga was born in Tanzania in 1952. He obtained a Bachelor of Science degree in forestry from the University of Dar-es-Salaam (Tanzania) in 1979 and a Master of Science degree in forestry from the Sokoine University of Agriculture (Tanzania) in 1987. In 1989 he obtained a Post Graduate Diploma in seed pathology at the Royal Veterinary and Agricultural University (Denmark). In 1990 he studied seed technology at the Danish Seed Testing Station and at the Danish International Development Assistance (Danida) Forest Seed Centre, both in Denmark. In the same year Danida awarded him a research fellowship at the Danish Government Institute of Seed Pathology (Denmark) to conduct research on seed-borne fungi of indigenous trees of Tanzania and their significance in causing diseases.

His first appointment, in 1979, was as a research officer in the Silvicultural Research Section of the Forestry Department, Government of Tanzania. In 1991 he was transferred to the National Tree Seed Programme, where he served as head of the Seed Research and Development Section. In 1996 he was appointed programme manager.

Mr. Msanga has participated in the preparation of two monographs for the Food and Agriculture Organisation of the United Nations (FAO), *Food and fruit bearing forest species. Examples from Eastern Africa*, and *Some medicinal forest plants of Africa and Latin America*. He coauthored the book *Useful trees and shrubs for Tanzania: identification, propagation and management for agricultural and pastoral communities*. He has also published a number of research papers in international scientific journals and proceedings of international conferences and symposia.

This book is the result of more than sixteen years of academic research during various stages of higher learning and work experience in the field of indigenous tree seeds of Tanzania.

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INTRODUCTION

Indigenous trees in Tanzania (Figure 1) were once abundant in their natural habitats (Mnzava 1980). Forest clearing for cash crop agriculture, and illegal felling inside forest reserves and elsewhere, have caused such over-exploitation that tree populations have been reduced to the extent that they can no longer recover through natural regeneration. This is a serious situation, and some endemic and rare tree species are now threatened with extinction. Examples of threatened tree species of economic importance are: *Allanblackia stuhlmannii* (mkimbo), *Beilschmiedia kweo* (mfimbo), *Bussea massaiensis* (mbefu), *Cephalosphaera usambarensis* (mtambara), *Cordyla densiflora* (mkwata), *Entandrophragma excelsum* (mbokoboko), and *Podocarpus usambarensis* (podo).

The government of Tanzania recognises the seriousness of this situation, and there are plans to reforest exploited areas with the original species. The importance of planting indigenous trees can not be over-emphasized. As tropical hardwoods become more and more scarce globally, prices will rise. It is hoped that eventually higher prices may compensate for the slow growth of these species, so that management becomes profitable.

Indigenous trees are also favoured over introduced trees by farmers for planting in agroforestry systems. This preference for indigenous trees is based on several factors. These include familiarity, the fact that they are generally better adapted to their environment than exotics, and the multipurpose role that they play in:

- providing human food;
- improving soil fertility;
- providing wood for various end uses;
- providing fodder and shelter for livestock;
- providing human and veterinary medicines; and
- preserving water catchments and controlling soil erosion.

Growing public awareness of the diverse values of indigenous trees has increased the scale of their planting. Since most of these trees are propagated from seeds, there has been a greater emphasis on rapid expansion of seed production. This has created new opportunities and problems in seed handling.

The present cost of producing seeds, and the extensive use of seedlings by the government and by non-government organisations, create a need for critical examination of all phases of seed handling. Among the factors requiring consideration are seed germination characteristics of economically and socially important indigenous trees. Two of the major difficulties encountered with these species are a low germination percentage and a prolonged germination period. These are serious matters because they result in spotty seedbeds containing seedlings of different ages and sizes, tie up the nursery area for extended periods, and lead to seed waste and high seedling cost.

Voluminous literature has accumulated on germination of seeds of agricultural crops and temperate trees (Margot 1975; Bewley and Black 1978; Berrie 1984; USDA 1974) but little is understood about this process in tropical forest trees. Only scanty information on seed handling and germination characteristics is available for indigenous trees of Tanzania. Furthermore, it is often fragmented, being frequently included in works mainly concerned with other silvicultural aspects of the species (Watkins 1960; Tietema *et al.* 1992; Albrecht 1993; Mbuya *et al.* 1994).

Before the 1960s, the Tanzanian government's plan had been to reforest exploited areas by planting fast-growing exotic trees to meet timber requirements. Reforestation with indigenous trees was given a low priority. As a result, little or no effort was directed to research on indigenous trees (Shehaghilo 1982). Thus germination studies for seeds of local trees did not receive serious attention. Now, with the change of

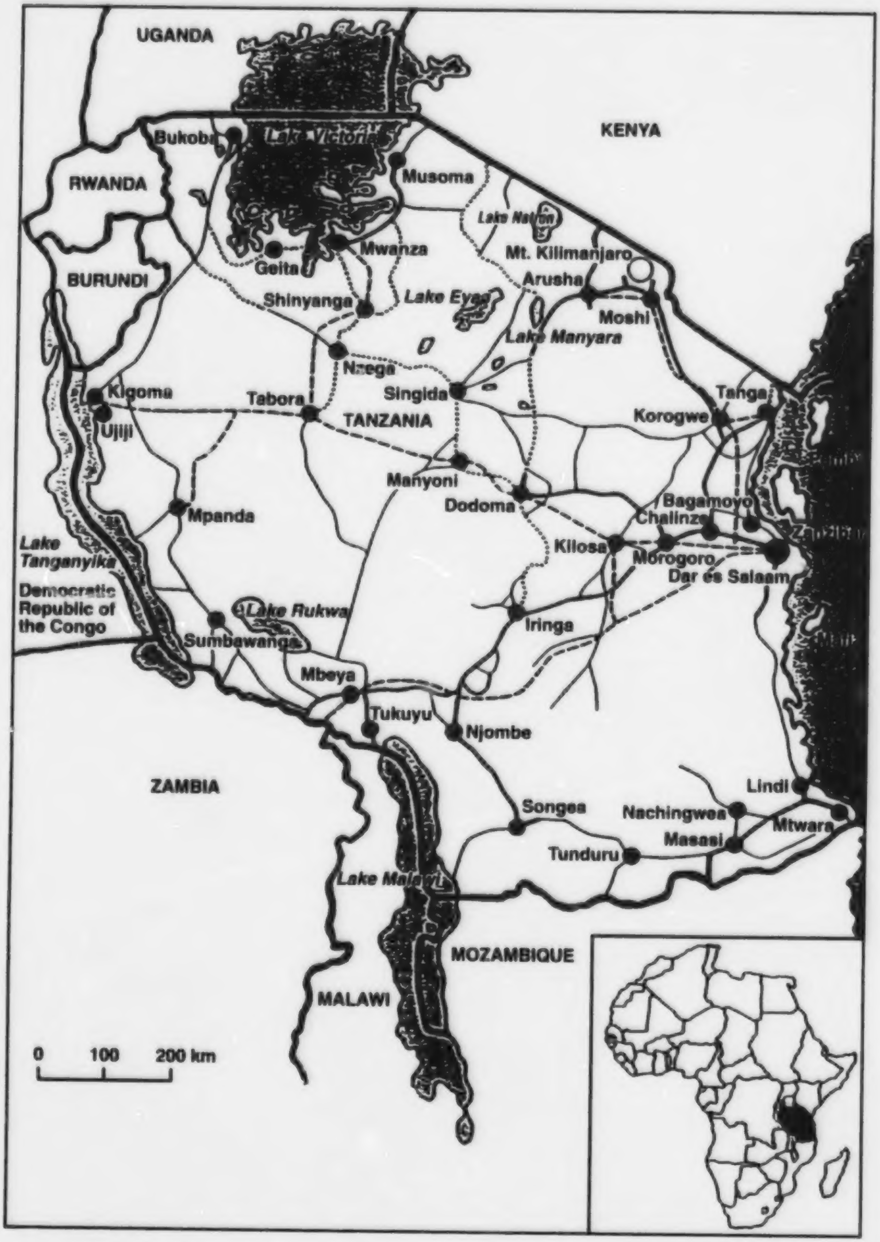

UGANDA
KENYA
RWANDA
BURUNDI
Lake Victoria
Bukoba
Musoma
Lake Natron
Mwanza
Geita
Mt. Kilimanjaro
Arusha
Shinyanga
Lake Eyasi
Moshi
Lake Manyara
Nzega
Kigoma
Ujiji
Tabora
Singida
TANZANIA
Tanga
Korogwe
Manyoni
Dodoma
Bagamoyo
Chalinze
Mpanda
Lake Tanganyika
Kilosa
Morogoro
Dar es Salaam
Zanzibar
Mafia
Democratic Republic of the Congo
Lake Rukwa
Sumbawanga
Iringa
Mbeya
Tukuyu
Njombe
ZAMBIA
Lindi
Songea
Nachingwea
Mtwara
Masasi
Tunduru
Lake Malawi
MOZAMBIQUE
MALAWI
0
100
200 km

Figure 1. Map of Tanzania.

attitude to indigenous trees, there is a need for much better understanding of how seeds of these trees can be collected, stored and germinated; it is clear that scientific efforts should be focused on these aspects. Otherwise, reforestation programmes and projects based on indigenous trees will be hampered.

Every time seed is to be sown, specific questions should be addressed:

- Will the seed germinate?
- How long will it take from sowing to commencement of germination?
- How long will it take from sowing to completion of germination?
- How long will it take from commencement of germination to completion of germination?
- What is the germination percentage?

These questions are addressed in this book. Their answers are important in estimating sowing density, planning for transplanting the germinating seeds from the seedbed into pots, and predicting when to abandon the seedbed. This information is needed for budgeting and planning nursery operations as well as planning land preparation before outplanting.

Seed testing procedures are an essential component of this process. One aim of testing seed is to ascertain the germinability of a small preliminary seedlot to determine seed requirements before a large collection is undertaken. Also, during the course of storage, germination tests should be carried out at regular intervals to determine the quality of the seeds and their losses in storage so that seedlots of poor quality can be purged.

It should be noted that the data on imbibition periods, germination percentages and germination periods refer to freshly processed seeds which were germinated in sand under ambient conditions. The storage periods indicated may not be accurate because there is no fixed period during which seeds can be stored without harm and after which they lose viability. Loss of viability is a gradual process, and its rate depends on many factors, particularly intrinsic longevity of the species, initial seed quality and storage conditions.

The best packaging for storage of orthodox and intermediate seeds is a sealed plastic container. For recalcitrant seeds packaging materials are mentioned separately for individual species.

Since seeds of each species were collected from only one source, and only a few treatments were applied, conclusions presented here should be treated as a general guide; they require confirmation through further research.

Genus and family nomenclature and assignments conform to the databases of the Royal Botanic Gardens, Kew, as do standard abbreviations of authorities for genera and species. Nomenclature for species, subspecies, varieties and synonyms conform to the W^{3}TROPICOS database of the Missouri Botanical Garden, as do authorities.

A glossary of commonly used terms is included.

Viable seeds of some species fail to germinate readily when exposed to suitable conditions for germination, i.e. when provided with adequate moisture, oxygen and light, and suitable temperatures. These seeds are said to possess dormancy. Seed dormancy can be of two types, seed coat dormancy or embryo (physiological) dormancy. Dormancy causes problems in seed testing and seedling production. In nurseries, seed dormancy causes low germination percentages and prolonged germination periods; these can have serious cost and scheduling implications, as previously noted. Simple, appropriate pretreatment methods can often alleviate the problem.

Overcoming Seed Coat Dormancy

Hot water

Water is heated to the boiling point, then removed from the heat source and immediately poured on the seeds, contained preferably in an aluminium or plastic container. As a rule of thumb, the volume of seeds to water should be in the ratio 1:5. The seeds should be stirred vigorously for a few minutes and left to soak as the water cools to room temperature. Figure 2 demonstrates the procedure for the hot water treatment, and Figure 3 shows a comparison between swollen and unswollen seeds of umbrella thorn tree (*Acacia tortilis*) following treatment.

There is a danger of injuring or cooking the embryo of some species if the temperature of the seeds becomes too high, i.e. if too much hot water is applied or if the soaking period is too long. The treatment may also be ineffective if the treatment is too gentle, and seeds are insufficiently heated. When the treatment is properly applied, the seeds imbibe water and start to swell as the water cools. When the treatment is not effective some seeds remain unswollen, even after prolonged soaking. Unswollen seeds should be separated from the swollen seeds and soaked again. Swollen seeds should be sown immediately.

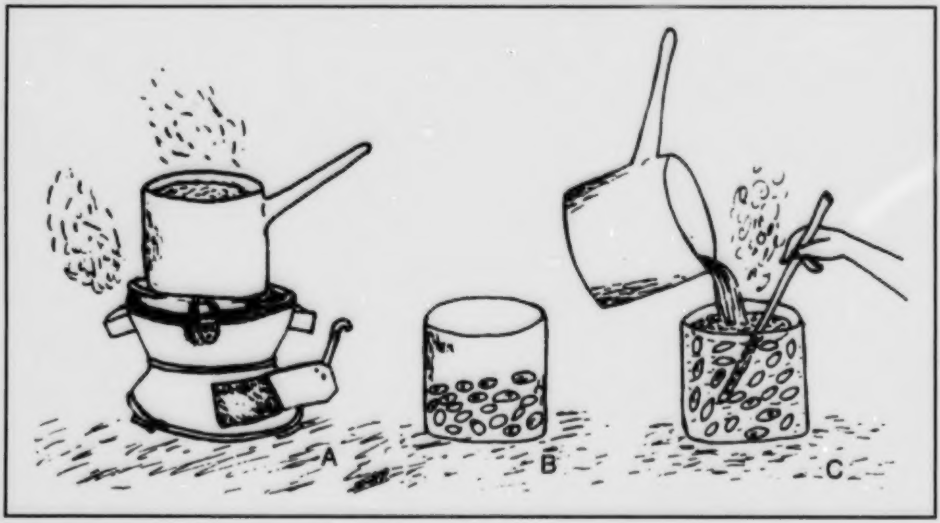


Figure 2. **Hot water treatment. (A)** Boiling 5 L of water, **(B)** 1 L of seed, **(C)** 5 L of boiling water poured onto seed, stirred and left to cool to room temperature.

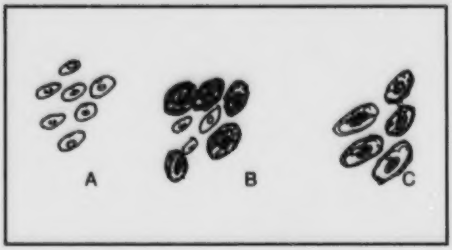


Figure 3. Swollen and unswollen seeds of *Acacia tortilis* following the hot water treatment. (A) Seeds before treatment, **(B)** mixture of swollen and unswollen seeds, cooled to room temperature after soaking in hot water, **(C)** swollen seeds after unswollen seeds are removed following treatment.

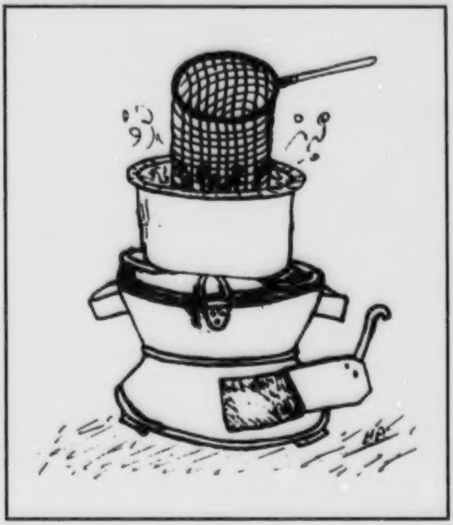


Figure 4. Boiling treatment.

Boiling

In this method seeds are packed in mosquito gauze, or any netting material which allows free circulation of water (but will not melt), and then placed into continuously boiling water for a specified period of time (Figure 4). The seed is then quickly transferred into cold water. The abrupt cooling causes fine cracks in the seed coat which allow entry of water and gases.

Cold water

Many hard-coated seeds germinate more readily after soaking for 24 to 48 hours in water at ambient temperature. Fresh water should be used if possible; prolonged soaking in stagnant water may serve to soften the seed coats, but, unless the water is changed daily, there is a risk of injury to the seeds due to lack of oxygen. The optimal duration of continuous boiling or soaking in cold water depends on the requirements of the individual species or seedlot, and is detailed for each species.

Manual scarification

With manual scarification methods, seeds are treated by rubbing on rough surfaces (e.g. sandpaper), or filing, chipping, or splitting the seed coat of individual seeds with a knife, scalpel, chisel or small hammer, while avoiding damage to the endosperm or embryo (Figures 5 and 6). When using sandpaper, seed should be scarified until a faint colour of the inner coat appears. Care should be taken to avoid overtreatment which may cause damage to internal seed structures. Where damage occurs, the seed should be discarded. The best site for scarification is that part of the seed coat where the radicle will emerge.

Hot wire

Another method of scarification is to use an electric burner commercially known as a "glowbrander" or hot wire. In this method, when the point of the hot wire (red glowing iron) touches the seed coat for 0.5 second, a small brown hole and some fine cracks are made on the outer impermeable layer of the seed coat (Figure 7).

Cement mixer

For treatment of large quantities of seed, the seeds may be mixed with gravel or crushed glass in a cement mixer and mixed vigorously for some

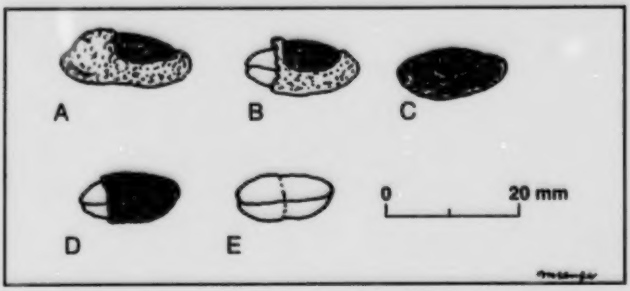


Figure 5. **Types of manual seed coat scarification of *Trichilia emetica* seed, using a scalpel.** **(A)** Unscarified seed, **(B)** partial removal of seed coat at the radicle end, **(C)** complete removal of aril, **(D)** complete removal of aril and partial removal of seed coat at the radicle end, and **(E)** complete removal of seed coat.

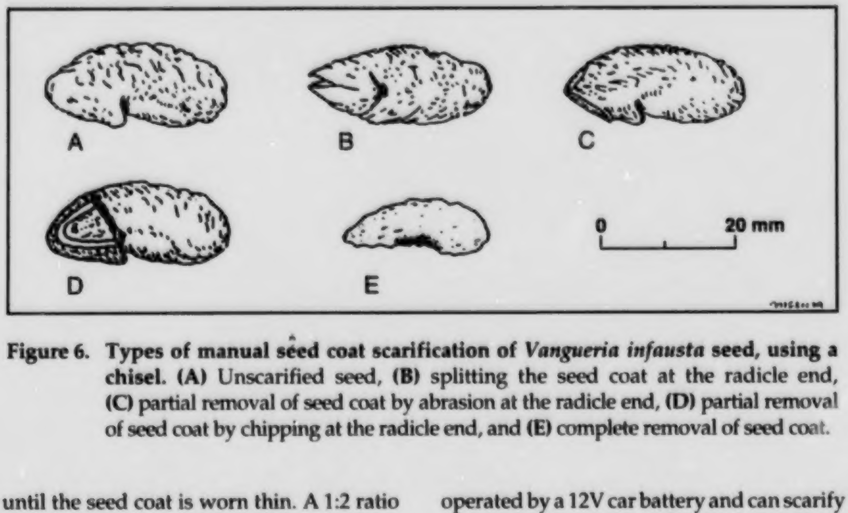


Figure 6. **Types of manual seed coat scarification of *Vangueria infausta* seed, using a chisel.** **(A)** Unscarified seed, **(B)** splitting the seed coat at the radicle end, **(C)** partial removal of seed coat by abrasion at the radicle end, **(D)** partial removal of seed coat by chipping at the radicle end, and **(E)** complete removal of seed coat.

time until the seed coat is worn thin. A 1:2 ratio of gravel to seed is generally recommended.

Seed gun

The seed gun, or "impaction mechanical scarifier" (Figure 8), works by throwing the seeds against the wall of a metal cylinder filled with sand. The seed is thrown against the inner wall at a speed of around 15 m/sec. The mechanical impact causes fine invisible and visible cracks in the outer layers of the seed coat. The seed gun is operated by a 12V car battery and can scarify 1 kg of seed in 10 minutes. For further information about the manufacturing and performance of the seed gun, contact Danida Forest Seed Centre, Krogerupvej 21, Dk 3050, Humlebaek, Denmark.

Chemical scarification

In some cases, such as large scale operations, acid scarification may be used. The following methods, as described by Goor and Barney (1968), may be applied. The seeds are completely

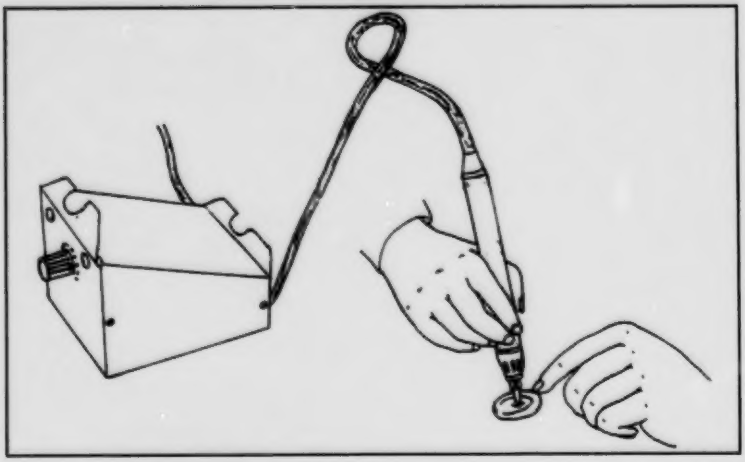


Figure 7. Seed pretreatment by hot wire.

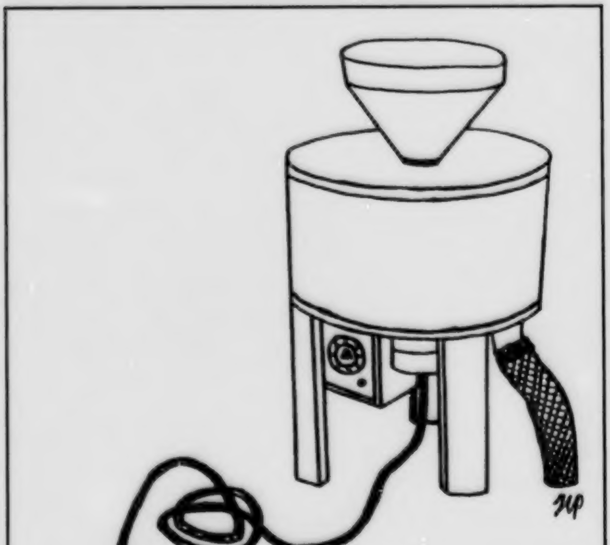


Figure 8. External view of seed gun.

immersed in concentrated sulphuric acid (H_2SO_4, 95% or 36N) in an acid-resistant container (plastic or glass). One kg of seed should be immersed in about 1 L of acid for the required period of time at room temperature. The seeds are then removed from the acid (which can be recovered and reused) and immediately washed thoroughly in cool running water to remove all traces of acid. A large amount of water at the start of the washing should be used, and the mixture stirred carefully to avoid splashing.

A less severe acid treatment can be applied by pouring acid over a heap of seeds (using approximately 25 mL of acid to 1 kg of seed), mixing the acid thoroughly with the seeds by turning with a wooden stirrer, and then washing the seeds thoroughly in running water.

Over-soaking may corrode the seed coat and even expose the embryo. Insufficient soaking leaves the seed coat glossy; coats of correctly treated seeds are dull, but not corroded. It is therefore suggested that a preliminary test should be undertaken to determine the optimum prescription for each species or even seedlot. After treatment and washing the seeds may be dried and stored, or sown immediately.

Acids are not widely recommended for seed presowing treatments because they are dangerous to people and material, and hazardous to the environment. Operators should wear acid-resistant protective clothing, including gloves and eye protection. Acids should not be used if other effective treatments are available.

Bleach has been shown to be more effective than acid for scarifying seed of some tree species (e.g. *Terminalia superba*), and can also control contamination by microflora (Khasa 1992).

Fire

In the savanna, fire is a powerful factor in removing seed dormancy and inducing natural regeneration. Sufficiently hot fires will increase seed coat permeability and stimulate germination. Light fires (controlled burns) have been used in this way to stimulate germination of seeds of *Pterocarpus angolensis*, while the impermeable seeds of *Acacia nilotica*, *Acacia tortilis* and other hard-coated acacias will germinate prolifically following fire, allowing rapid colonization of burnt areas. At Arusha National Park in northern Tanzania, regeneration of *Juniperus procera* is usually very dense after the seeds have been stimulated by light fires.

Biological methods

In nature, animals, birds and insects can be important factors in the breakdown of seed coat impermeability. In the game parks in Tanzania, seeds of *Acacia* spp., *Tamarindus indica*, *Adansonia digitata*, *Grewia* spp. and others that have passed through the digestive tracts of wild animals such as antelopes and elephants show a higher germination rate than untreated seeds.

Insects play a big role in breaking seed coat dormancy for seeds with hard seed coats. Indeed, one of the methods used to increase seed germination in *Pterocarpus angolensis* is to allow termites to eat the tough wings and bristles of the fruit. Puncturing of the seed coat by small beetles (*Bruchidus* spp.) can contribute to dormancy-breaking in seeds of species such as *Acacia tortilis*, *Erythrina abyssinica* and *Faidherbia albida* and, where sufficient moisture is available, seeds can germinate before being killed by the developing larvae.

Overcoming Embryo Dormancy

This type of dormancy is not common in seeds of indigenous trees of Tanzania. Methods for overcoming embryo dormancy have been described separately for individual species where necessary.

Seed Size

The size of seed is defined according to the number of seeds per kilogram (ISTA 1993).

Large:	less than 22 000 seeds per kilogram
Medium:	22 000 to 130 000 seeds per kilogram
Small–medium:	130 000 to 660 000 seeds per kilogram
Small:	more than 660 000 seeds per kilogram

Germination Tests

The use of standardized optimal conditions for seed germination in the laboratory, such as those prescribed in the International Seed Testing Association (ISTA 1993) rules, is not always completely feasible, and these rules are not detailed in this book. However, the basic principles and some of the basic rules of ISTA should be followed as much as possible.

Substrate and germination equipment

The substrate is defined as the non-living material upon which seed germinates, or medium on which the seeds are placed for germination. The main requirements for the substrate (Justice 1972) are that it be:

- non-toxic to the germinating seedling;
- free of fungi and other microorganisms; and
- porous in texture to enable adequate aeration and moisture for the germinating seeds.

Soil is not a suitable substrate for germination tests because soil samples will vary greatly in physical, chemical and biological properties. Soil-based germination tests may be more comparable to germination under field conditions, but poor repeatability and difficulty in comparing tests of different seedlots render them unsuitable.

Filter paper

Three layers of filter paper (e.g. Whatman No. 1) or any other absorbent paper meeting the above substrate requirements are laid inside transparent plastic dishes of variable size depending on seed size; e.g. plastic dishes, size 18 × 12 × 6 cm, or petri dishes, 9 cm diameter. However, petri dishes are often too small for medium to large tropical tree seeds, and may result in serious mould development. The same situation may occur with the use of a paper substrate for relatively large seed germination tests.

Sand

If the test is performed outdoors, open-ended wooden boxes of internal dimensions 25 cm × 25 cm and depth of 20 cm may be used (Figure 9). The boxes are laid on the ground and filled to a depth of 19 cm with fine sand from which organic matter and silt have been washed away.

If the test is performed indoors, aluminium bowls of diameter 20 cm and depth of 8 cm may be used (Figure 10). The bowls are filled with fine sand from which organic matter and silt have been washed away. They are left at ambient temperature and natural day light (near a window, but out of direct sunshine) or kept inside a germination room with artificial light for a minimum of eight hours per day.

Sowing seeds

Sowing seeds on filter paper

Germination tests can be carried out indoors, preferably in a germination cabinet (Figure 11) with artificial light. This method is recommended for small and medium sized seeds. A random sample from a seedlot is taken and separated into four replicates, each containing 100 seeds. If 100 seeds overcrowd the filter paper in one container, the replicates may be separated into several smaller replicates of 50 or 25 seeds each. The seeds are uniformly distributed in each container over the surface of the filter paper. The rule of thumb is to leave a space of two times the average

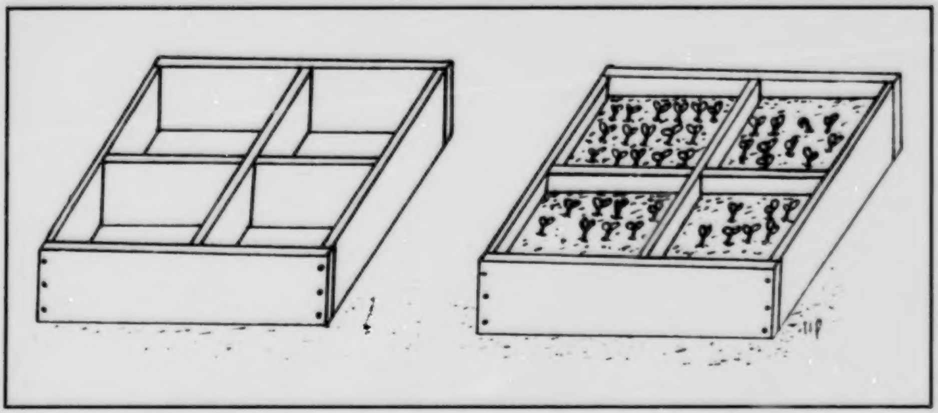


Figure 9. An outdoor germination test in sand.

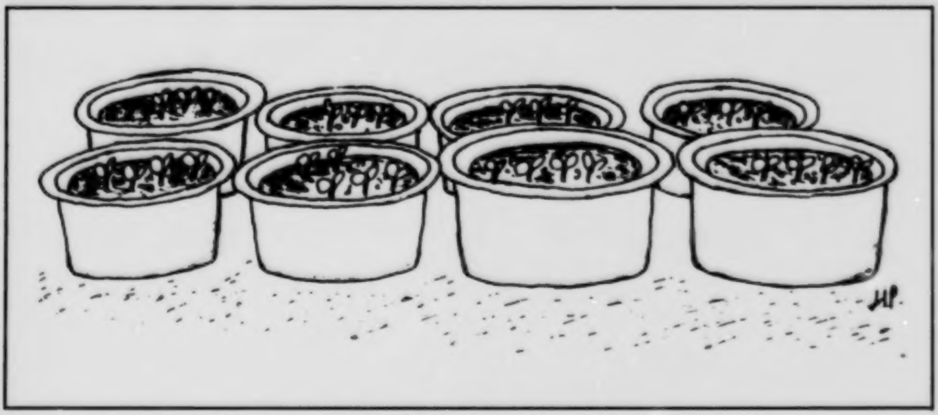


Figure 10. An indoor germination test in sand.

seed width between seeds, in order to avoid cross-contamination by microflora.

The filter paper in the container should be moistened with clean water (preferably distilled water) at the beginning of the test. Thereafter the substratum should be kept moist at all times, but not so wet that a film of water forms around the seeds. The containers are covered and placed in a germination cabinet or left at ambient temperature with natural light (near a window, but out of direct sunshine).

Sowing seeds in sand

This method is recommended for medium and large sized seeds. As for the previous procedure, a random sample from a seedlot is taken and separated into four replicates, each containing 100 seeds. Smaller replicates (25 to 50 seeds) could be used for larger seeds, although

Figure 11. A germination cabinet.

germination estimates will be somewhat less accurate. The seeds are uniformly distributed in each box or bowl by pressing them with a thumb or board into the surface of the sand, which should be moistened to field capacity. For testing purposes, seeds should be covered with sand to a uniform depth of one to two times the average seed width. Subsequent moistening may be required before the test is terminated. Water should be applied manually in a fine spray as needed so that the sand is kept moist at all times without becoming water-logged.

Evaluation of germination

Where seeds are sown on filter paper, they are considered to have germinated when the protruding shoot (epicotyl) has reached at least 1 cm in length and exhibited negative geotropism, the root (radicle) has extended to a length at least equal to the length of the seed, and all essential seedling structures are normal. Seeds which are obviously dead and decayed must be removed at every assessment to avoid cross-contamination of healthy seed by microflora.

Where seeds are sown in sand, the criterion for epigeal germination is a visible protrusion of the cotyledons, hypocotyl and epicotyl above the surface of the sand (Figure 12). In the case of hypogeal germination, germination can be said to have occurred when there is a visible protrusion of the epicotyl alone (Figure 13). Other examples are presented in Table 1.

Germination should be evaluated every day, or at regular intervals of several days, depending on the speed of germination.

Germination variables

Germination percentage

Germination percent is the percentage of seeds considered to have germinated according to the criteria above within a specified period, depending upon the species and germination conditions. At each evaluation the number of germinated seeds in each replicate is expressed as a percentage of seeds sown. From this an average germination percentage for the seedlot is calculated by adding all the replicate percentage values and dividing by the number of replicates.

In this book, where figures are not given, germination percentage has been described as follows:

80–100% = very good
60–79% = good
30–59% = fair
1–29% = poor
0% = nil

Germination energy

Germination energy is the germination percentage attained when the mean daily germination speed (cumulative germination percentage

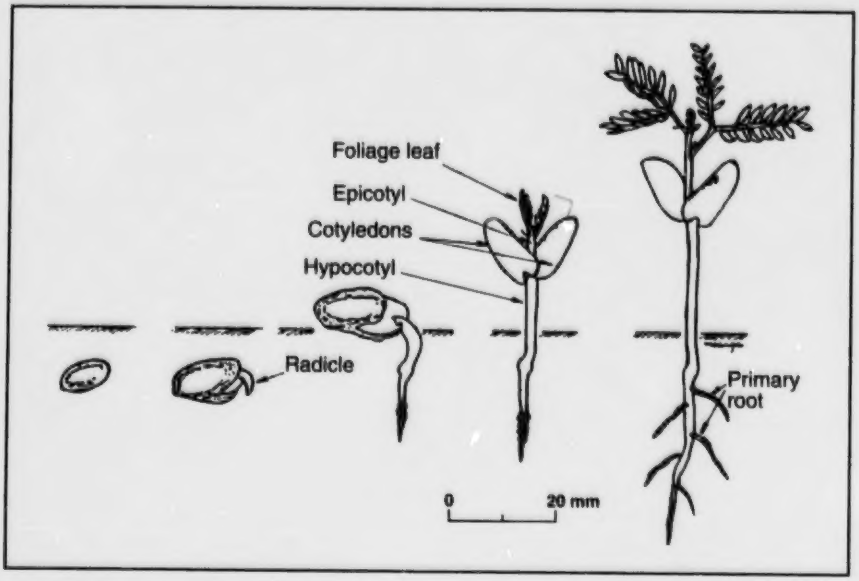

Foliage leaf
Epicotyl
Cotyledons
Hypocotyl
Radicle
Primary root
0
20 mm

Figure 12. Epigeal germination: apple-ring acacia, *Faidherbia albida*.

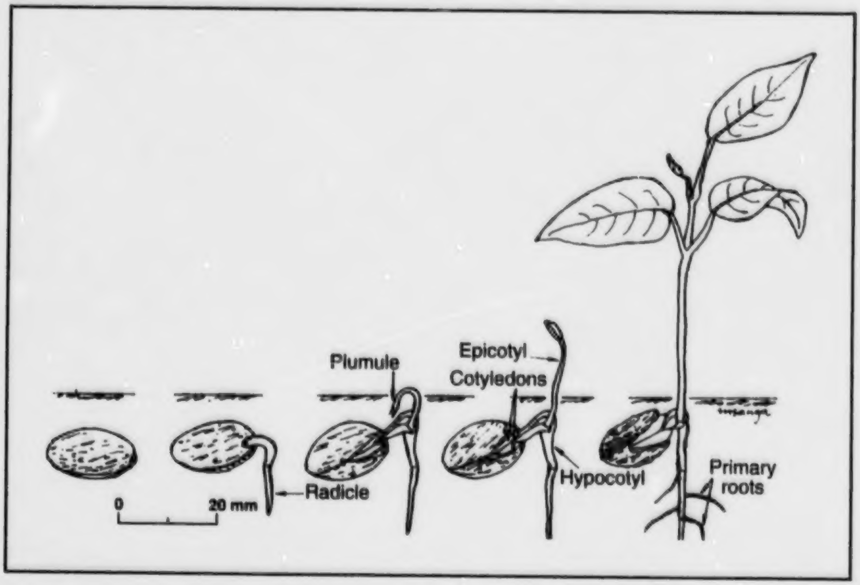

Plumule
Epicotyl
Cotyledons
Hypocotyl
Radicle
Primary roots
0
20 mm

Figure 13. Hypogeal germination: mkunguma, *Sorindeia madagascariensis*.

Table 1. Some species exhibiting hypogeal, epigeal and intermediate germination modes

Type of seed	Type of germination		
	Hypogeal	Epigeal	Intermediate
Endospermic	*Allanblackia stuhlmannii* *Garcinia livingstonei* *Osyris lanceolata* *Sorindeia madagascariensis* *Ximenia americana*	*Croton megalocarpus* *Diospyros mespiliformis* *Manilkara obovata* *Podocarpus usambarensis* *Treculia africana*	*Sterculia quinqueloba* *Uapaca kirkiana* *Vangueria infausta*
Nonendospermic	*Beilschmiedia kweo* *Cordyla africana* *Erythrina abyssinica* *Ocotea usambarensis* *Syzygium guineense*	*Acacia nilotica* *Brachystegia spiciformis* *Erythrina burttii* *Faidherbia albida* *Tamarindus indica*	*Balanites aegyptiaca* *Bauhinia petersiana* *Clerodendrum cephalanthum*

divided by the time elapsed since sowing date) has reached its peak (Willan 1985).

Germination value

Germination value (Gv) is a composite value which combines both germination speed and total germination. It provides an objective means of evaluating the results of germination tests, and allows comparisons among seedlots of the same species. It is calculated by using the formula of Djavanshir and Pourbeik (1976):

$$Gv = (\Sigma DGs/N)\, Gp/10$$

Where

Gv = Germination value;

Gp = Cumulative germination percent after a specified time;

DGs = Daily germination speed; obtained by dividing the cumulative germination percent by the number of days since sowing, i.e. Gp/D;

D = Number of days since sowing;

ΣDGs = The total obtained by adding DGs figures obtained from the daily counts;

N = The number of daily counts, starting from the date of first germination.

An example is given in Table 2.

Germination periods

The imbibition period (the number of days from sowing to commencement of germination), the total germination period (the number of days from sowing to completion of germination), and the differential germination period (the number of days from commencement to completion of germination, or the difference between the total germination and imbibition periods) can also be determined.

In this book, where figures are not given, the differential germination period has been described as follows:

Less than one week = uniform

One to three weeks = moderately or fairly uniform

More than three weeks = sporadic

Rapid Viability Tests

For seeds of some species, germination takes place very slowly even after pretreatment; for such seed, germination tests are not suitable for

Table 2. Calculation of germination energy and germination value for a *Trichilia emetica* seedlot at the end of a germination test

D	Gp	DGs = Gp/D	ΣDGs	N
12	4	0.33	0.33	1
13	4	0.31	0.64	2
14	4	0.29	0.93	3
15	12	0.80	1.73	4
16	24	1.50	3.23	5
17	40	2.35	5.58	6
18	52	2.89	8.47	7
19	60	3.16	11.63	8
20	72	3.60	15.23	9
21	88	4.19	19.42	10
22	92	4.18	23.60	11
23	96	4.17	27.77	12

Germination percentage = 96
Germination energy = 88
Germination value = (ΣDGs/N) Gp/10
= 27.77/12 × 96/10
= 22.22

assessing germination potential. If the total germination period is expected to exceed 60 days a rapid test should be used. Rapid tests are also useful for short-lived recalcitrant seeds, where viability of the seedlot could decline markedly while germination tests were being carried out.

Rapid viability tests are also sometimes used to determine seed quality before processing, storage or distribution. Detailed descriptions of methods are available in Gordon *et al.* 1991; ISTA 1993; Bhodthipuks *et al.* 1996; and Bonner *et al.* 1994. For these tests a sample size of four replicates of 25 to 50 seeds for large seed, or four replicates of up to 100 seeds for smaller seeded species, may be used.

Cutting test

This is the quickest and simplest rapid viability test. The cutting test can also be used to determine the quality of ungerminated seed after a standard germination test. This method is suitable for species with delayed germination, such as *Allanblackia stuhlmannii* and *Xymalos monospora.* It is especially useful for species known to have a high proportion of empty seeds which cannot be separated by flotation (e.g. *Terminalia sericea, Combretum zeyheri* and *Maesopsis eminii).*

In this method seeds are cut in half longitudinally and the embryo examined. Results can be classified as follows:

Appearance	Viability
firm, white or greenish-white	alive
firm, brown	dead
soft, rotten	dead
empty	no embryo; inviable
containing insect larvae instead of embryo	inviable

This method is difficult to use with very small seeds.

Tetrazolium

This rapid viability testing method can be completed within seven days, depending on species (Yu and Wang 1996). It is suitable for species with delayed germination, such as *Bersama abyssinica* and *Brackenridgea zanguebarica*.

Seeds are soaked in water and, after imbibition, the seed coat is peeled off and the seed cut in half to expose the embryo (and endosperm if present). One half of each seed is immersed in a 1% solution of tetrazolium chloride (2,3,4-triphenyl tetrazolium chloride) or bromide in darkness for 24 hours at room temperature.

Tetrazolium chloride is reduced by enzymes from live tissue to form a red precipitate (formazan) which stains the surface of the embryo and endosperm. Viable seeds will stain red, while dead seeds will remain partially coloured or colourless.

One disadvantage of this test is the difficulty of interpreting stain intensity and distribution.

Excised embryo

This method is good because actual embryo performance is tested; the test is also easy to evaluate. It is suitable for seeds with delayed germination, such as *Adansonia digitata* and *Berchemia discolor*.

Seeds are soaked in water and, after imbibition, the seed coat is peeled off. The embryo is extracted and placed on moist filter paper in petri dishes or germination boxes and incubated at alternating regimes of 25°C in darkness for 12 hours and 30°C in light for 12 hours. Within five to 14 days, viable embryos will be green or white, and exhibit some growth. Non-viable embryos will be dark or brown, and unchanged in size.

Disadvantages of this test are that it relatively slow, and is not practical for very small seeds.

Hydrogen peroxide

This method is simple and may be suitable for seeds with delayed germination, such as *Adansonia digitata*, *Berchemia discolor* and *Brackenridgea zanguebarica*.

Seeds are soaked overnight and the tip of the seed coat is carefully sliced off or abraded to expose the radicle. Seeds are then incubated in 1% hydrogen peroxide (H_2O_2) in darkness at temperatures of 20–25°C. The hydrogen peroxide should be changed after three days. After seven days, if the radicle growth is 5 mm or greater in length, the seed may be classed as good; if less than 5 mm growth, the seed is of poor viability; and if there is no radicle growth, the seed is non-viable.

A disadvantage of this method is its impracticability for very small seeds. It is also relatively slow.

X-ray radiography

The seeds are exposed to X-ray radiation, and the image formed on film is examined for presence, structure and development of embryo, cotyledons, and megagametophyte or endosperm. This method is beyond the scope of this book.

An advantage of this method is that no seed are destroyed, so small seedlots or very valuable seed are not wasted. However, equipment and supplies can be difficult to obtain, and are very expensive to purchase and maintain.

Seedbed Preparation and Sowing

How to make a seedbed

A timber frame about 25–30 cm high should be made (Figure 14). Bricks, stones or logs can also be used. The boards forming the edge of the frame should be buried 5 cm into the ground, and should be supported on the outside by pegs driven into the ground. The width of the bed can be 1 m and the length can be several metres, depending on requirements. The bed should be filled in layers as follows:

bottom: gravel (depth: 5 cm);
middle: mixture of forest top soil and sand in the ratio 1:1 by volume (depth: 10 cm);
top: fine sand from which organic matter and silt have been washed away (depth: 5 cm).

The seedbed should not be filled completely, or else the top sand and seed will be washed away. The surface should be made level and firm by applying a flat board.

The seedbed should be screened in order to provide shade to the germinating seeds. Screens are constructed at a height of 2 m from the ground, and may be built of straw or straight sticks about 2 cm in diameter tied about 2 cm apart with string. The screens are supported over the bed on a frame of poles and withes. The sides should be left open for ventilation (Figure 14).

Nylon or plastic netting material may be used as a screen to provide shade for the whole nursery, and will also prevent the sun from shining in from the sides. It also makes it easier to keep the atmosphere of the nursery cool and less arid, and is very pleasant to work under.

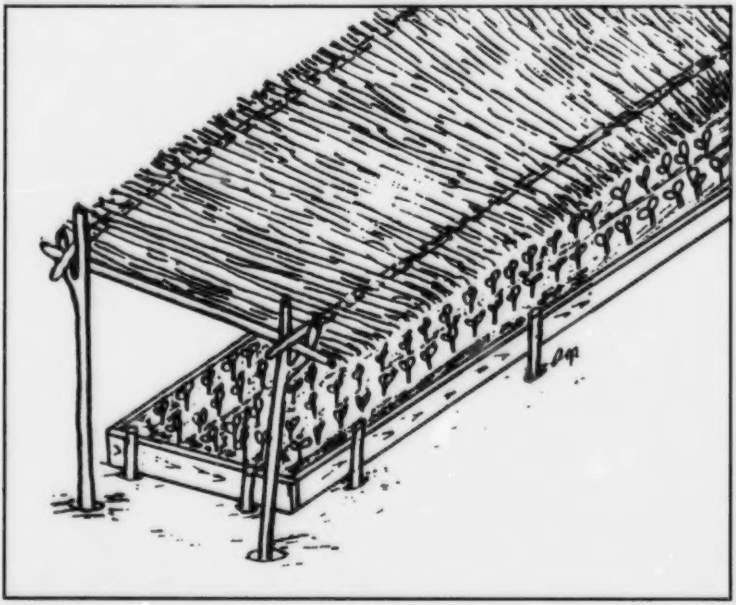


Figure 14. A seedbed with shade cover.

Seed sowing

Seeds should be uniformly distributed on the seedbed. A space two times the average seed width should be left between the seeds in order to avoid cross-contamination by microflora. As a rule of thumb, seeds should also be covered with sand to a uniform depth of two to three times the average seed width. Watering with a fine spray should be done so that the sand is kept moist all the time without becoming water-logged.

In the rainy season seeds should be sown with surface mulch but without shade, to avoid the danger of drip damage below the shade.

Soil Mixture Preparation, Pot Filling, Direct Sowing and Transplanting

Soil mixture preparation and pot filling

There are various potting soil mixtures which can be used, depending on locality and species. The most common one is composed of composted cow manure, fine sand and forest top soil in a 1:2:3 ratio by volume. The preferred top soil is the top soil layer from a dense montane or riverine forest. Failing this, ordinary bush top soil may be used. All ingredients should be sieved first in order to remove clods and stones. If the mixture is a little dry, it should be watered and turned several times. The soil should be light but cohesive, and not fall out of the pot when it is handled.

The pots (also called polyethylene tubes or polybags) may be about 6 cm diameter (i.e. 10 cm width when laying flat) and 14 cm long. Other sizes may also be used, and pots may be black or transparent. The pots should be filled in stages and the soil gently firmed at each stage, avoiding compaction. If pots are filled all at once, air pockets will result.

Direct sowing of seed into pots

Sometimes seeds may be sown directly into pots. This method is suitable for medium and large sized seeds with a very good germination percentage. One or two (or more) seeds, depending on germination percentage, are directly sown in each pot. The seed should be placed at the centre of the pot and covered with the potting mixture or fine sand, to a depth of one to two times the average seed width (Figure 15). Water in a fine spray should be applied in such a way that the sand is kept moist at all times without becoming water-logged.

Transplanting into pots

When the young seedlings have just started to produce their first leaves they should be transplanted, or pricked out, from the seedbed into pots (Figure 16). A dibble hole, deeper than the length of the roots, should be made so that the root ends are not curled up. Also, the hole should be made wide enough, otherwise the lateral roots will catch the side and point upwards as the seedling goes in.

When transplanting, the seedling should be held only by the cotyledons, not by the stem. The young tap root may be cut back, if necessary, to about 4 cm length. The seedlings should be transplanted to a depth slightly greater than in the seedbed. If secondary roots have developed, hold the seedling in the half-filled pot and sprinkle the soil lightly around the roots until the pot is filled. This will avoid root damage or deformation. Soil should be firmed gently around the roots.

The seedling bed should be framed in the same way as for the seedbed, so that pots are held upright and are not exposed to the sun's radiation from the sides (Figure 17).

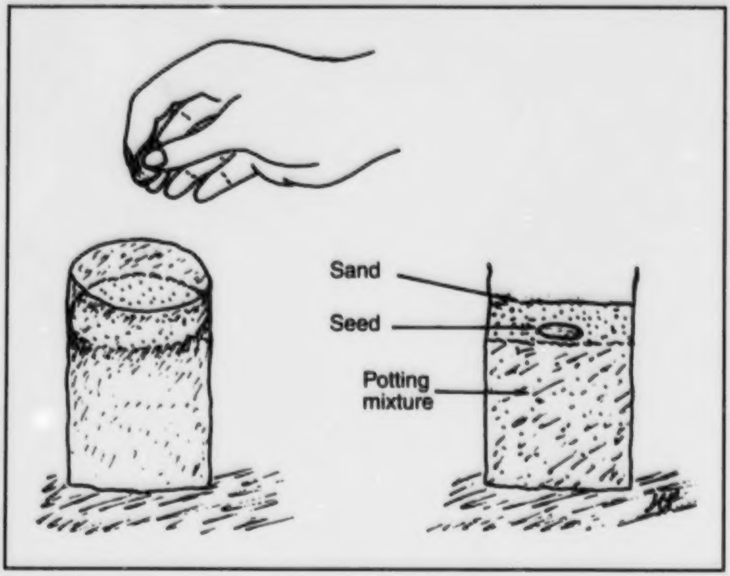

Sand
Seed
Potting mixture

Figure 15. Direct sowing into a pot.

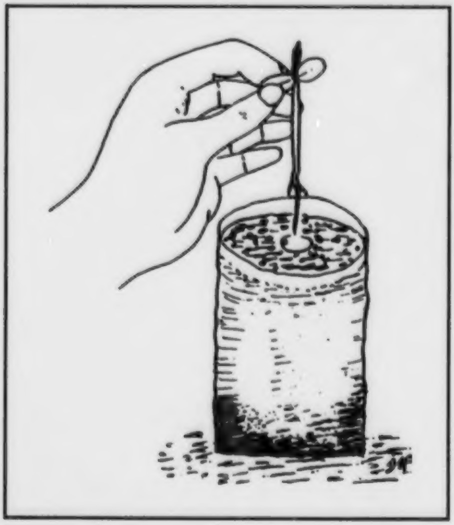


Figure 16. Transplanting a seedling into a pot.

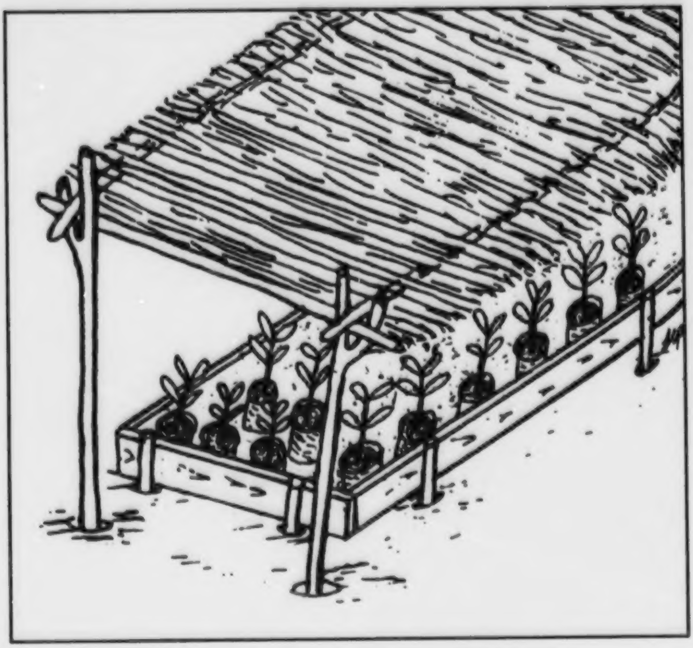


Figure 17. Transplanted seedling pots in a seedling bed.

FRUIT AND SEED CHARACTERISTICS OF INDIVIDUAL TREE SPECIES

Acacia drepanolobium Harms ex Sjöstedt

LEGUMINOSAE: MIMOSOIDEAE

Other names

Black galled acacia, whistling thorn.

Fruit morphology and seed extraction

The fruit is a pod, green at first, turning red-brown when ripe, narrow and elongated, curved, about 2.5 cm long and slightly hairy, containing up to seven seeds. The pods should be dried in the sun for a few days then threshed in a gunny bag using a stick. Seeds are cleaned by shaking and winnowing. About 6 kg of dry pods produce 1 kg of seeds.

Seed morphology

The seed is slightly elongated with blunt angles, flat, about 8 mm long and 5 mm wide, brown, and compressed, with a hard seed coat. The flat faces are marked by a faint line parallel to the outline of the seed. There are about 26 000 seeds per kilogram.

Seed storage

The seed is orthodox and can be stored for three years at room temperature without significant loss of viability if kept dry and free of insects.

Seed presowing treatment

The seed does not require any pretreatment, but soaking in cold tap water for six hours hastens germination.

Seed germination

Germination is epigeal (Figure 18). The radicle emerges first, then the hypocotyl elongates and carries the cotyledons above the germination medium. The seed coat usually remains partly enclosing the cotyledons until they open, when it falls off. The cotyledons change from white to green but later shrivel and turn brown.

Germination is very good and uniform, attaining 90% after six days and 95% after ten days from sowing.

Plant uses

The tree is nitrogen-fixing and is useful for soil improvement, particularly in areas which are occasionally water-logged. The leaves and pods form a valuable source of game feed. The stem and branches are used for building livestock pens.

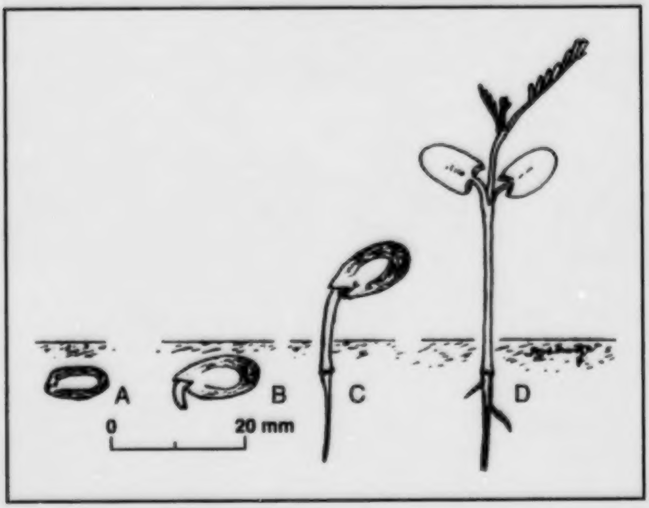


Figure 18. **Stages in seed germination and early development of *Acacia drepanolobium* seedlings. (A)** At sowing, **(B)** at 2 days, **(C)** at 4 days, **(D)** at 6 days after sowing.

Acacia nilotica (L.) Willd. ex Delile
LEGUMINOSAE: MIMOSOIDEAE

Other names

Scented-pod acacia; mgunga (Kiswahili); ol-kiloriti (Kimasai); kijame (Kirangi); msasao (Kinyiramba).

Fruit morphology and seed extraction

The fruit is a pod (Figure 19) up to 17 cm long, 2 cm wide, green and fleshy when young, becoming darker when mature, straight or curved, and slightly constricted between the seeds. It does not split open, but breaks transversely into single-seeded segments when the fruit falls on the ground. Each fruit contains up to 18 seeds. Dry pods are pounded in a mortar to extract the seeds, which are separated from the broken pods by shaking and winnowing. Another method, for large quantities, is to use a "flailing thresher" (modified agricultural thresher) to break the pods apart, and an "air-screen" machine to clean or winnow the seeds by removing lighter debris. About 5 kg of dry pods yield 1 kg of clean seeds.

Seed morphology

The seed is almost round and slightly flattened. On each edge of the two flat sides there is a light line which follows the seed outline. The seed is dark brown and glossy, with a hard seed coat, and is about 7 mm long and 5 mm wide. There are about 6000 seeds per kilogram.

Seed storage

The seed is orthodox and can be stored for five years at room temperature without significant loss of viability, if kept dry and free of insects.

Seed presowing treatment

Small quantities of seed may be pretreated using a hot wire. When bulk quantities are to be pretreated, the seed gun may be used at a speed index which will give a crack percentage of about 50%. The hot water and boiling treatments are both also effective for this species (*see* section on seed presowing treatments). For the boiling treatment, a boiling period of three minutes is suggested.

Seed germination

Germination is epigeal (Figure 20). The radicle emerges first, then the hypocotyl elongates, slightly bent, and carries the cotyledons above the germination medium. The seed coat usually remains partly enclosing the cotyledons until they separate, when it falls off. The cotyledons later shrivel and fall off.

Germination is good and fairly uniform after pretreatment, attaining 40% after 10 days and 74% after 20 days from sowing.

Plant uses

The tree provides firewood, charcoal, poles, bee forage, dye, fodder, and edible gum. It is also useful for nitrogen fixation and soil conservation.

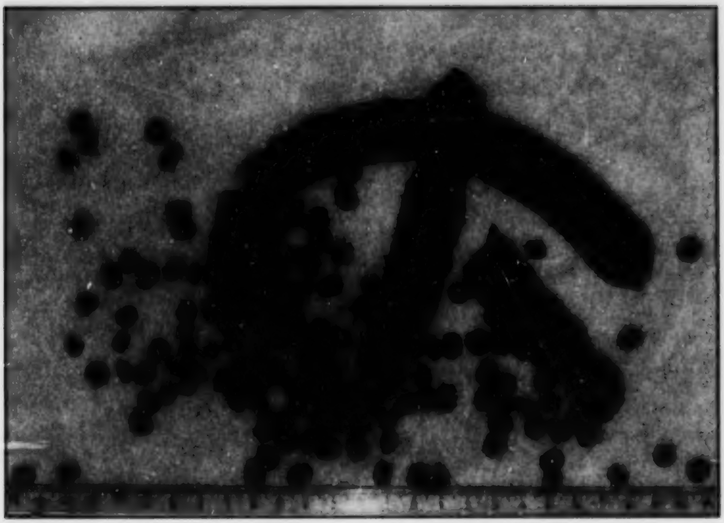


Figure 19. *Acacia nilotica* pods and seeds.

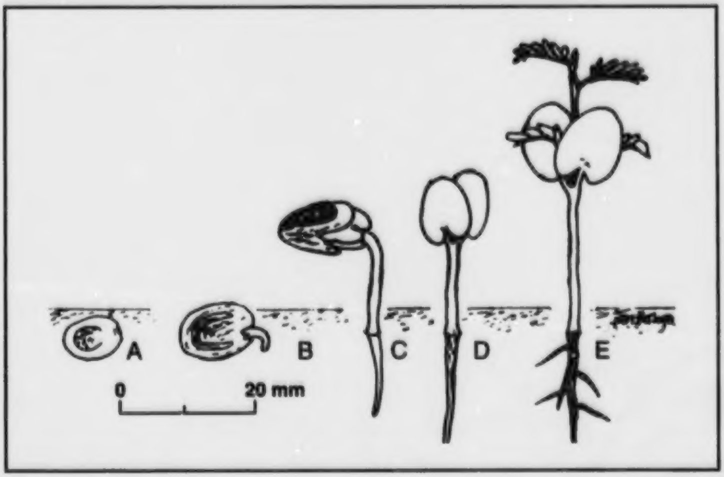


Figure 20. Stages in seed germination and early development of *Acacia nilotica* seedlings. (A) At sowing, (B) at 3 days, (C) at 6 days, (D) at 8 days, (E) at 25 days after sowing.

Acacia polyacantha Willd. subsp. *campylacantha* (Hochst. ex A. Rich.) Brenan

Syn. *Acacia campylacantha* Hochst. ex A. Rich.

LEGUMINOSAE: MIMOSOIDEAE

Other names

White thorn-tree, falcon's claw acacia; mkengewa, mgunga (Kiswahili); muwindi (Kigogo); msukanzi (Kihehe); livindwe (Kinyamwezi); mugu (Kisukuma); mkukuku (Kihaya).

Fruit morphology and seed extraction

The fruit is a straight flat pod, dark brown at maturity, 10 cm long and 2 cm broad, tapering to each end, and containing up to eight seeds. The pods should be dried in the sun for a few days, then threshed in a gunny bag with a stick. Seeds are cleaned by shaking and winnowing. About 5 kg of dry pods will produce 1 kg of seeds.

Seed morphology

The seed is slightly elongated with blunt angles, flat, about 9 mm long and 6 mm wide, greenish brown, and compressed, with a hard seed coat. The flat faces are marked by a faint line parallel to the outline of the seed. There are about 14 000 seeds per kilogram.

Seed storage

The seed is orthodox and can be stored for three years at room temperature without significant loss of viability if kept dry and free of insects.

Seed presowing treatment

Small quantities may be pretreated using a hot wire. Bulk quantities of seed should be pretreated by the hot water method (*see* section on seed presowing treatments).

Seed germination

Germination is epigeal (Figure 21). The radicle emerges first, then the hypocotyl elongates, bending slightly, and carries the cotyledons above the germination medium. The seed coat usually remains partly enclosing the cotyledons until the cotyledons separate and it falls off. The cotyledons change from white to green, and later become brown and shrivelled.

Germination is very good and uniform. It reaches 50% after 12 days and 77% after 20 days from sowing.

Plant uses

The tree provides excellent firewood and termite-resistant timber. The leaves and pods provide feed for livestock and game animals. The tree is good for nitrogen fixation, soil improvement and shade near houses.

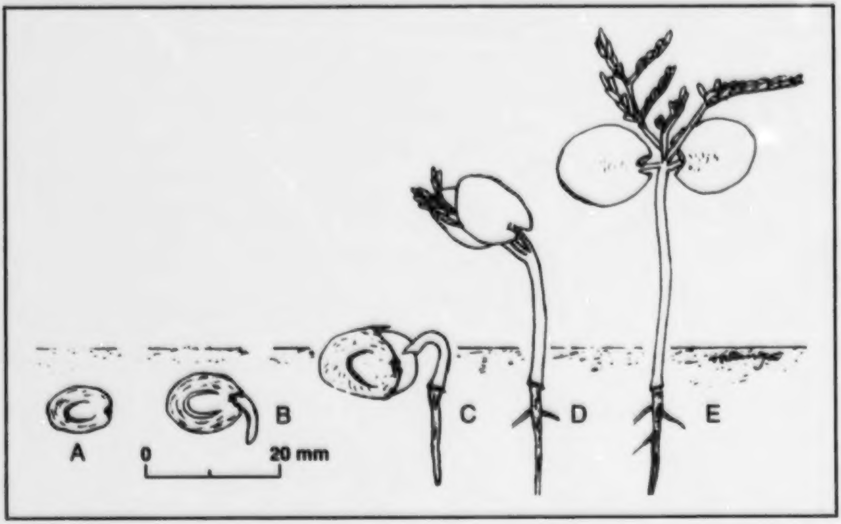


Figure 21. **Stages in seed germination and early development of *Acacia polyacantha* seedlings.** **(A)** At sowing, **(B)** at 4 days, **(C)** at 8 days, **(D)** at 10 days, **(E)** at 14 days after sowing.

Acacia senegal (L.) Willd.

LEGUMINOSAE: MIMOSOIDEAE

Other names

Three-thorned acacia, gum arabic; kikwata (Kiswahili); mgwata (Kinyamwezi, Kisukuma); mzasa (Kigogo); muhunga (Kirangi).

Fruit morphology and seed extraction

The fruit is an elongated pod, usually 8 cm long and 3 cm broad, very thin, and straw-coloured. Pods contain up to five seeds, and usually exhibit some constrictions due to abortion of some seeds. The pods should be dried in the sun for a few days, then threshed in a gunny bag with a stick. Seeds are cleaned by shaking and winnowing. About 5 kg of dry pods produce 1 kg of seeds.

Seed morphology

The seed is slightly elongated with blunt angles, flat, about 13 mm long and 10 mm wide, greenish brown and compressed, with a hard seed coat. The flat faces are marked by a line parallel to the outline of the seed. There are about 10 000 seeds per kilogram.

Seed storage

The seed is orthodox, and can be stored for three years at room temperature without significant loss of viability if kept dry and free of insects.

Seed presowing treatment

The seed does not require any pretreatment, but soaking in cold tap water for six hours hastens the germination process.

Seed germination

Germination is epigeal (Figure 22). The radicle emerges first, then the hypocotyl elongates, bending slightly, and carries the cotyledons above the germination medium. The seed coat usually remains partly enclosing the cotyledons until the cotyledons separate and it falls off. The cotyledons change from white to green; later they become brown and shrivelled.

Germination is very good and uniform. It attains 65% after 15 days and 95% after 20 days from sowing.

Plant uses

Acacia senegal gum, or gum arabic, has many industrial uses. The stem is used for tool handles and firewood, while the bark produces fibre used for ropes, and the leaves and pods are a valuable source of game feed.

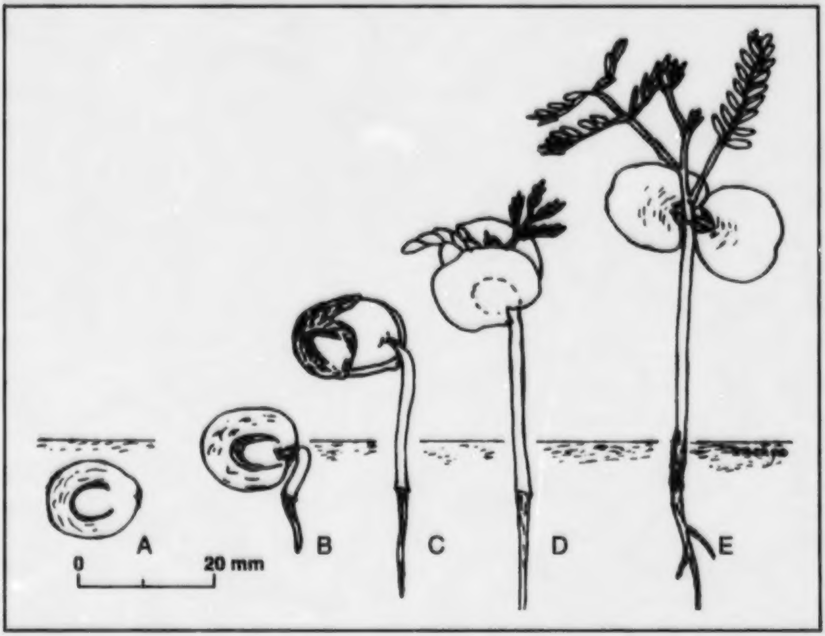


Figure 22. **Stages in seed germination and early development of *Acacia senegal* seedlings. (A)** At sowing, **(B)** at 3 days, **(C)** at 7 days, **(D)** at 15 days, **(E)** at 20 days from sowing.

Acacia sieberiana DC.

LEGUMINOSAE: MIMOSOIDEAE

Other names

White thorn, paper bark thorn; nsungwa (Kinyakyusa); msua (Kisukuma); mlaka (Kigogo).

Fruit morphology and seed extraction

The fruit is a straight woody pod, about 10–22 cm long and 1.8–3.5 cm wide, and contains 12–15 seeds arranged in a row and embedded in spongy tissue; it does not split open at maturity. Ripening pods are collected from trees, and drying completed in the sun. Alternatively, dry pods may be collected from the ground soon after natural shedding. Dry pods are heaped on a tarpaulin or hessian sheeting material and beaten well with sticks to extract seeds. For extraction of large quantities of seeds a flailing thresher can be used. About 20 kg of pods produce 1 kg of seeds.

Seed morphology

The seed is brown, smooth, almost circular, and compressed, with a hard seed coat. It is about 10 mm long and 8 mm wide. Each of the flat surfaces has a distinct circular marking which roughly follows the outline of the seed. There are about 4000 seeds per kilogram.

Seed storage

The seed is orthodox and can be stored for up to five years at room temperature without significant loss of viability, if kept dry and free of insects.

Seed presowing treatment

Small quantities may be pretreated using a hot wire. Another method is to nick the seed coat at the scar end using a sharp tool such as a razor blade, knife or nail clipper. Care should be exercised to make sure that the cut is not so deep as to injure the radicle. Bulk quantities should be pretreated using a seed gun at a speed index which will give a crack percentage of about 50%. The hot water and boiling treatments are both appropriate for this species (*see* section on seed presowing treatments). For the boiling treatment the suggested boiling period is three minutes.

Seed germination

Germination is epigeal (Figure 23). The seed absorbs water and swells. The radicle emerges from the scar end, then the hypocotyl elongates and carries the cotyledons above the germination medium. The seed coat is either left inside the germination medium or carried up on the cotyledons until they unfold, when it falls off. The cotyledons later become brown and shrivelled. The first leaf is compound with 11 pairs of leaflets.

Germination is good and fairly uniform, attaining 30% after 14 days and 65% after 25 days from sowing.

Plant uses

Ripe pods have an edible spongy tissue. The gum produced by the stem is also edible. The stem and branches are used for firewood and hut building, while the leaves and pods provide fodder for livestock and game. A decoction of the bark is used in the treatment of gonorrhoea.

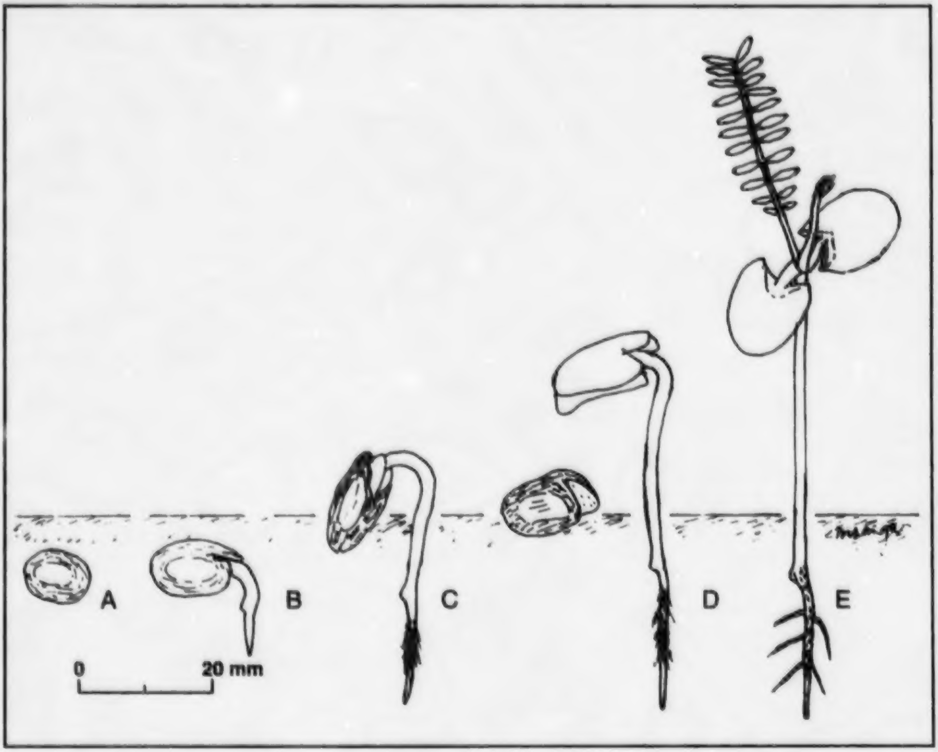


Figure 23. **Stages in seed germination and early development of *Acacia sieberiana* seedlings.** (A) At sowing, (B) at 5 days, (C) at 10 days, (D) at 15 days, (E) at 25 days after sowing.

Acacia tanganyikensis Brenan
LEGUMINOSAE: MIMOSOIDEAE

Other names

Mgunga (Kiswahili).

Fruit morphology and seed extraction

The fruit is a large flat pod, pale yellow when mature, 20 cm long and 3 cm wide. Pods contain an average of seven seeds. Dry pods are heaped on sheeting material and beaten well with sticks to detach the seeds. Seeds are cleaned by shaking and winnowing. For extraction of bulk quantities a flailing thresher and an air-screen cleaner may be used (as for *Acacia nilotica).* About 12 kg of pods produce 1 kg of seeds.

Seed morphology

The seed is slightly elongated with blunt angles, flat, about 12 mm long and 8 cm wide, straw coloured, and compressed, with a hard seed coat. The flat faces are marked by a line parallel to the outline of the seed. There are about 6000 seeds per kilogram.

Seed storage

The seed is orthodox and can be stored for three years at room temperature without significant loss of viability, if kept dry and free of insects.

Seed presowing treatment

Small quantities may be pretreated using a hot wire. Another method is to nick the seed coat at the scar end of the seed using a sharp tool such as a razor blade, knife or nail clipper. Care should be exercised to make sure that the cut is not so deep as to injure the radicle. The hot water treatment is appropriate for this species (*see* section on seed presowing treatments).

Seed germination

Germination is epigeal (Figure 24). The radicle emerges first, then the hypocotyl elongates, slightly bending, and carries the cotyledons above the germination medium. The seed coat usually remains partially enclosing the cotyledons until the cotyledons split and it falls off. The cotyledons change from white to green, and later become brown and shrivelled.

Germination is very good and uniform. It attains 80% after seven days and 90% after 10 days from sowing.

Plant uses

The stem and branches provide charcoal, firewood and poles recommended for hut building. The leaves and pods form a valuable source of game feed.

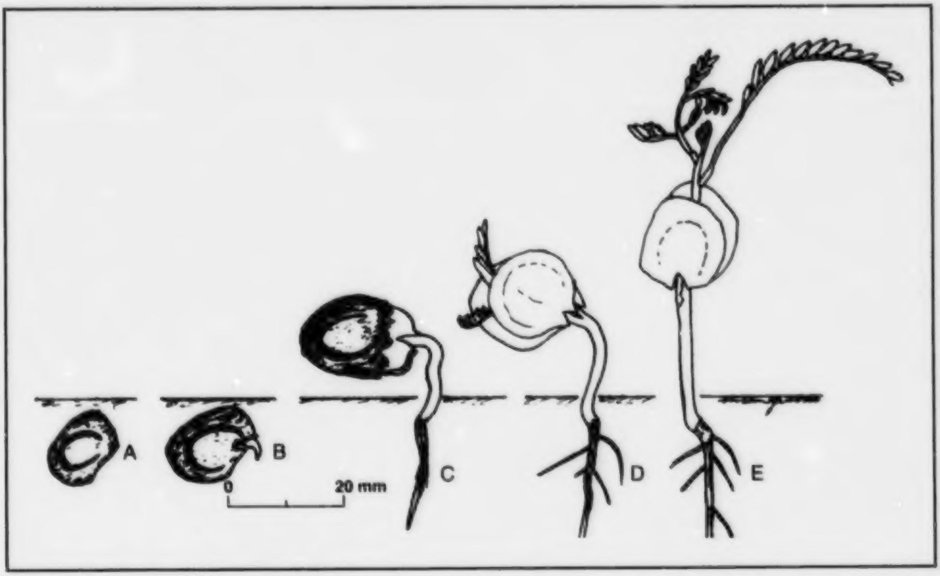


Figure 24. **Stages in seed germination and early development of *Acacia tanganyikensis* seedlings. (A)** At sowing, **(B)** at 3 days, **(C)** at 5 days, **(D)** at 6 days, **(E)** at 18 days after sowing.

Acacia tortilis (Forssk.) Hayne subsp. *spirocarpa* (Hochst. ex A. Rich.) Brenan

LEGUMINOSAE: MIMOSOIDEAE

Other names

Umbrella thorn; mgunga (Kiswahili); olgorete (Kimasai); mkungugu (Kigogo); mghara (Kipare).

Fruit morphology and seed extraction

The fruit is a pod, yellow-brown when ripe, spirally twisted, slightly constricted between the seeds, about 10 cm long and 0.7 cm thick. One pod contains five to ten seeds. Pods are picked from standing trees and dried in the sun for a few days. Alternatively the pods may be collected from the ground soon after natural shedding or after shaking the tree. The pods are heaped on a tarpaulin or hessian sheeting and beaten well with sticks to detach the seeds from the valves. The seeds are then cleaned by shaking and winnowing. For extraction of bulk quantities of seeds a flailing thresher and an air-screen machine are used (as for *Acacia nilotica*). About 6 kg of pods produce 1 kg of seeds.

Seed morphology

The seed is almost round and slightly flattened. On each edge of the two flat sides there is a light line which roughly follows the outline of the seed. The seed is light brown, glossy, and compressed, with a hard seed coat, and measures about 4 mm by 6 mm. There are about 18 000 seeds per kilogram.

Seed storage

The seed is orthodox and can be stored for five years at room temperature without significant loss of viability, if kept dry and free of insects.

Seed presowing treatment

Small quantities may be pretreated using a hot wire. When bulk quantities are to be pretreated the seed gun may be used at a speed index which will give a crack percentage of about 50%. The hot water (*see* Figure 3) and boiling treatments are both appropriate for this species (*see* section on seed presowing treatments). For the boiling method, a three minute immersion period is suggested.

Seed germination

Germination is epigeal (Figure 25). After the radicle emerges, the hypocotyl elongates and carries the cotyledons above the germination medium. The seed coat usually remains partially enclosing the cotyledons until they separate and it falls off. The cotyledons have short stalks. At first they turn from white to green; later they become brown and shrivelled. The first leaf is compound with nine pairs of leaflets.

Germination is very good after pretreatment, reaching 50% after seven days and 90% after 12 days from sowing.

Plant uses

The pod and leaves provide the main forage for cattle, sheep, goats and wildlife in semiarid and arid regions. The tree is excellent for soil stabilization. It is an attractive tree with a spreading, flat crown that provides year-round shade. The bark is used for making string, while the stem and branches are used for building livestock pens and as firewood. Other uses of this tree include nitrogen fixation, human medicine, live fencing, tannin, dyes, and bee forage.

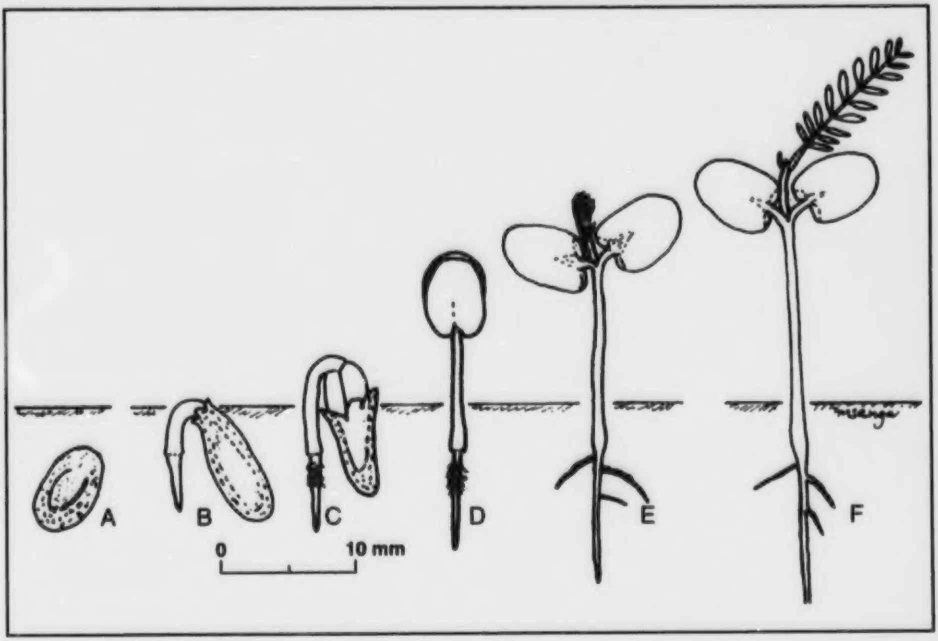


Figure 25. **Stages in seed germination and early development of *Acacia tortilis* seedlings. (A)** At sowing, **(B)** at 4 days, **(C)** at 7 days, **(D)** at 10 days, **(E)** at 15 days, **(F)** at 20 days after sowing.

Acacia xanthophloea Benth.

LEGUMINOSAE: MIMOSOIDEAE

Other names

Fever tree; mwerera (Kipare); mgunga (Kiswahili); olerai (Kiarusha); murya (Kinyaturu); mweda (Kirangi).

Fruit morphology and seed extraction

The fruit is a flat, yellow-brown pod. The margins exhibit a raised line which follows the outline of the pod. Pods are slightly constricted between seeds, and do not split open, but break into segments about 6 cm long and 1 cm broad, containing up to eight seeds. Seeds are extracted by pounding in a mortar and cleaned by winnowing. A flailing thresher machine can also be used. About 12 kg of pods produce 1 kg of seeds.

Seed morphology

The seed is flat and round, about 3 mm across, yellowish-green, with a hard seed coat. The flat faces are marked by a faint line almost parallel to the outline of the seed. There are about 30 000 seeds per kilogram.

Seed storage

The seed is orthodox, and can be stored for three years at room temperature without a significant loss of viability, if kept dry and free of insects.

Seed presowing treatment

Seeds may be pretreated using a hot wire. The hot water treatment can also be used (*see* chapter on seed presowing treatments).

Seed germination

Germination is epigeal (Figure 26). The radicle emerges first, then the hypocotyl elongates and carries the cotyledons above the germination medium. The seed coat usually remains partly enclosing the cotyledons until they separate and it falls off. The cotyledons later become brown and shrivelled.

Germination is very good and uniform after pretreatment. It attains 70% after seven days and 90% after 12 days from sowing.

Plant uses

The stem and branches are used for firewood, charcoal and poles. The tree also provides bee forage and is planted as an ornamental and a shade tree.

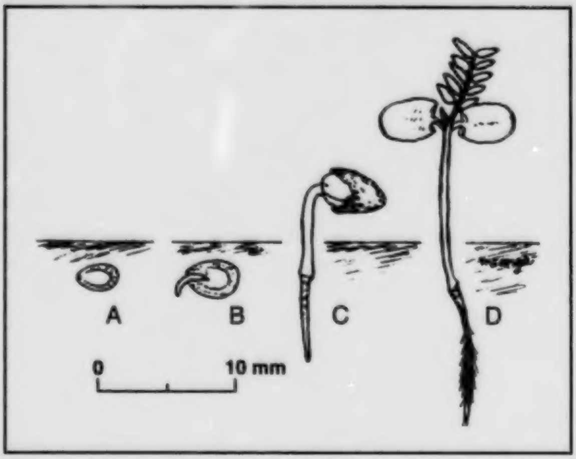


Figure 26. Stages in seed germination and early development of *Acacia xanthophloea* seedlings. (A) At sowing, (B) at 3 days, (C) at 5 days, (D) at 7 days after sowing.

Acokanthera schimperi (A. DC.) Schweinf.

APOCYNACEAE

Other names

Poison-arrow tree; mvusungu (Kipare); mchungu (Kiswahili); msungu (Kihehe); mshunguti (Kisambaa).

Fruit morphology and seed extraction

The fruit is a berry, purple to dark red, almost egg shaped, and about 2 cm long and 1.5 cm broad. It contains two seeds. The fruit skin and pulp are removed by macerating in water and then squashing by hand. The seeds are cleaned by washing in water. About 6 kg of fruits produce 1 kg of clean seeds.

Seed morphology

The seed is almost flat on one side, about 1.4 cm long and 0.7 cm broad, white, with rounded tips, with a mucilaginous covering like a coffee bean. There are about 6000 seeds per kilogram.

Seed storage

The seed is recalcitrant; it can retain viability for up to two months at room temperature.

Seed presowing treatment

The seed does not need pretreatment before sowing.

Seed germination

Germination is epigeal (Figure 27). The radicle protrudes and develops into a taproot. The hypocotyl elongates, bending slightly and soon straightening. The seed coat and cotyledons are carried above the germination medium by the hypocotyl. Later the seed coat falls off as the cotyledons expand. The cotyledons are leafy, and change colour from white to green.

Germination is very good and fast with fresh seeds, attaining 20% after 12 days and 80% after 20 days from sowing.

Plant uses

The fruit is edible. Care should be taken as the latex from the green fruit is poisonous. A paste obtained from boiled wood chips is used as an arrow poison. The wood is used for spear shafts and tool handles.

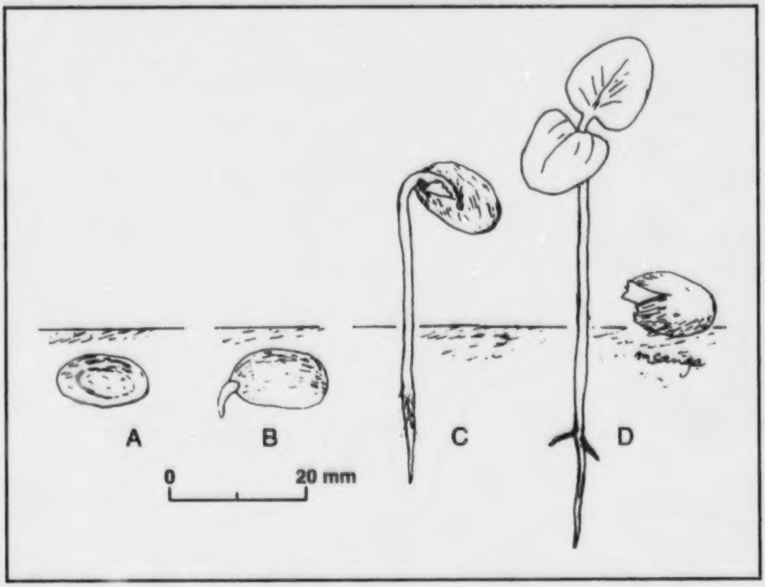


Figure 27. **Stages in seed germination and early development of *Acokanthera schimperi* seedlings. (A)** At sowing, **(B)** at 5 days, **(C)** at 8 days, **(D)** at 10 days after sowing.

Adansonia digitata L.
BOMBACACEAE

Other names

Baobab; mbuyu (Kiswahili); mramba (Kipare).

Fruit morphology and seed extraction

The fruit is a large woody capsule, slightly tapering at both ends, with a round tip. It is filled with white, dry pulp and many seeds. Ripe, dry fruits are collected from trees and smashed to release seeds, which are embedded in the pulp. The seeds together with the pulp are soaked in water for six hours to soften and macerate the pulp, which is removed from the seeds by gently squashing and floating in water. Seeds which float to the surface are discarded, while those which sink to the bottom are presumed to be viable and are retained. The seeds are dried in the sun for two days.

For extraction of bulk quantities, the seeds, together with the pulp, are soaked in water (as above) then mixed with gravel in a proportion by weight of one part gravel to two parts pulp (including seeds). This mixture is poured, together with large quantities of water, into a concrete mixer and stirred for some time. Then water, pulp and empty seeds are poured off, leaving filled seeds and gravel at the bottom. The gravel may be picked out by hand or separated from the seeds by using a sieve with mesh just small enough to retain the gravel. About 8 kg of fruits produce 1 kg of seeds.

Seed morphology

Seed is kidney-shaped with rounded tips and a hard, brown seed coat. It is about 12 mm long and 8 mm broad. There are about 2500 seeds per kilogram.

Seed storage

The seed is orthodox and can be stored for up to four years at room temperature without significant loss of viability, if kept dry.

Seed presowing treatment

Small quantities may be pretreated using a hot wire. For large quantities, the hot water treatment is appropriate (*see* section on seed presowing treatments). After cooling the seed should continue soaking in water for 12 hours.

Seed germination

Germination is epigeal (Figure 28). The seed coat cracks and the radicle protrudes from the scar end. The seed coat is carried up by the extending hypocotyl on the cotyledons. The leafy cotyledons expand greatly, and change colour from white to green.

Germination is good but sporadic, reaching 30% after four weeks and 65% after 12 weeks from sowing.

Plant uses

The fruit pulp is edible, and is also used to make a refreshing drink. In many arid areas, leaves are boiled and eaten as a vegetable; the seeds are also roasted and eaten. The bark provides fibre used in making ropes and strings, while the big white flowers are attractive and provide bee forage. Traditional bee-hives are generally suspended from this tree.

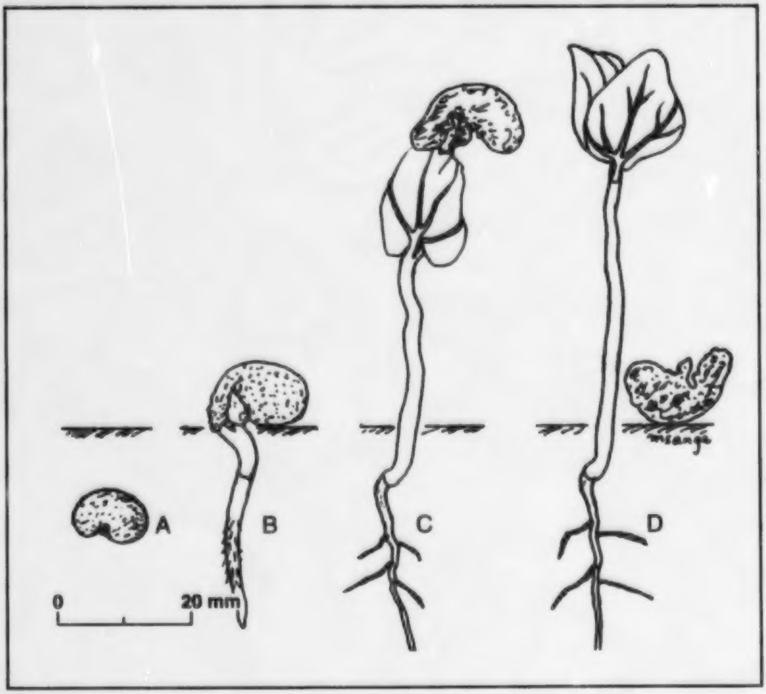


Figure 28. **Stages in seed germination and early development of *Adansonia digitata* seedlings. (A)** At sowing, **(B)** at 20 days, **(C)** at 25 days, **(D)** at 30 days after sowing.

Afzelia quanzensis Welw.

LEGUMINOSAE: CAESALPINIOIDEAE

Other names

Bean mahogany, pod mahogany, lucky bean tree; mkora, mkongo (Kiswahili); mkokola (Kipare); mkola (Kinyamwezi, Kisukuma).

Fruit morphology and seed extraction

The fruit is a large, thick, smooth, woody pod, approximately 17 cm long, 5 cm wide and 2 cm thick. At maturity it dries and opens like a spectacle case to release six or more seeds (Figure 29). Ripe pods are collected from trees and dried in the sun, then opened by hand to release seeds, or left to open by themselves. Alternatively, seeds may be collected from the ground soon after natural shedding. Five kg of fruits produce about 1 kg of seed.

Seed morphology

The seed is large and elongated, about 3 cm long and 1.5 cm wide, black, and tipped with a fleshy bright red aril at the scar end (Figures 29 and 30). There are about 485 seeds per kilogram.

Seed storage

The seed is orthodox and can be stored for up to five years at room temperature without significant loss of viability, if kept dry and free of insects.

Seed presowing treatment

The aril must be removed from the base, and a portion of the seed coat partly removed, using a knife or sand paper.

Seed germination

Germination is epigeal (Figure 30). The seed coat softens and ruptures to give way to the developing radicle. The root descends while the hypocotyl elongates, bending, and rises above the germination medium. The seed coat falls off in pieces, and the cotyledons, on exposure to light, change from white to green. They do not unfold, and usually remain closed up against the first leaves and stem.

Germination is uniform and very good. It reaches 90% after 20 days and 95% after 25 days from sowing.

Plant uses

Afzelia quanzensis is one of the finest timber trees in Tanzania and southern Africa. The young leaves are boiled and eaten as relish. The seeds are sold as curios and are strung into necklaces. The wood is used for many purposes, including furniture, flooring, building material, tool-handles, grain mortars and firewood.

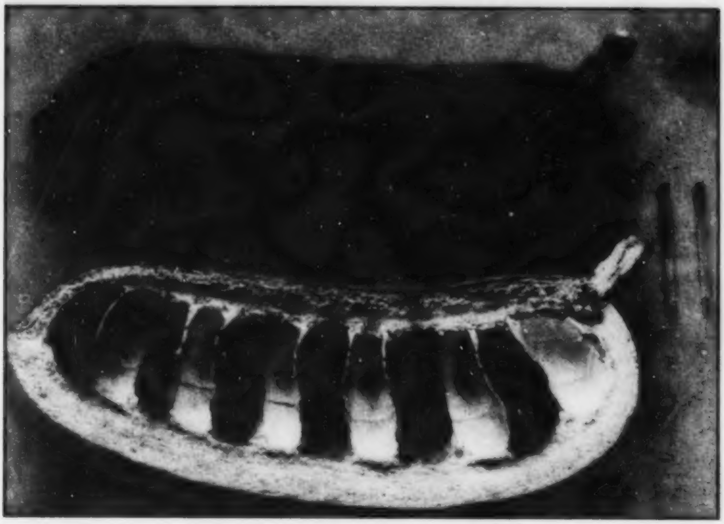


Figure 29. ***Afzelia quanzensis*** **pod and seeds.**

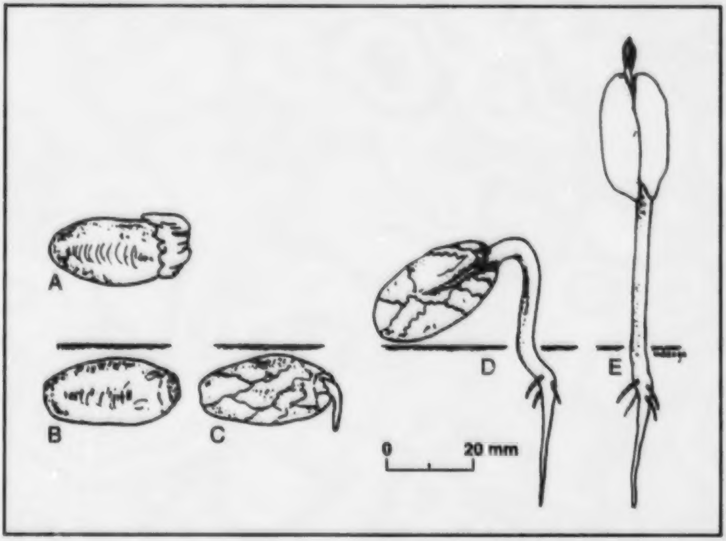


Figure 30. **Stages in the germination of *Afzelia quanzensis* seed. (A) Seed with its aril before treatment, (B) seed with both aril and part of seed coat removed at sowing, (C) at 5 days, (D) at 15 days, (E) at 30 days after sowing.**

Agelaea pentagyna (Lam.) Baill.

CONNARACEAE

Other names

Namkanza (Kipare).

Fruit morphology and seed extraction

The fruit is a pod about 1.5 cm long which opens along only one side to release one seed. The fruits are opened by hand to release the seeds. About 5 kg of fruits produce 1 kg of seeds.

Seed morphology

The seed is black and white, egg-shaped, about 8 mm across, with a cup-shaped fleshy aril at the base. There are about 2000 seeds per kilogram.

Seed storage

The seed is recalcitrant and should be packed in small quantities (less than 5 kg) in cotton bags to provide good ventilation. The seeds cannot tolerate desiccation below 20% moisture content and should not be stored at a freezing temperature. Seeds should be sown within four weeks after collection.

Seed presowing treatment

The seed does not require any pretreatment, but the aril should be removed from the base.

Seed germination

Germination is hypogeal (Figure 31). The radicle emerges at the scar point, then many adventitious roots soon differentiate at the base and grow rapidly to form the final root system, which has no definite taproot. The expanding epicotyl splits the two cotyledons apart and breaks through the seed coat, leaving the cotyledons within the seed coat buried in the germination medium.

Germination is very good and uniform. It reaches 80% after 15 days and 100% after 20 days.

Plant uses

The young branches are used for ropes and the stem is used for making walking sticks. The plant is important for water catchment planting in rainforest areas.

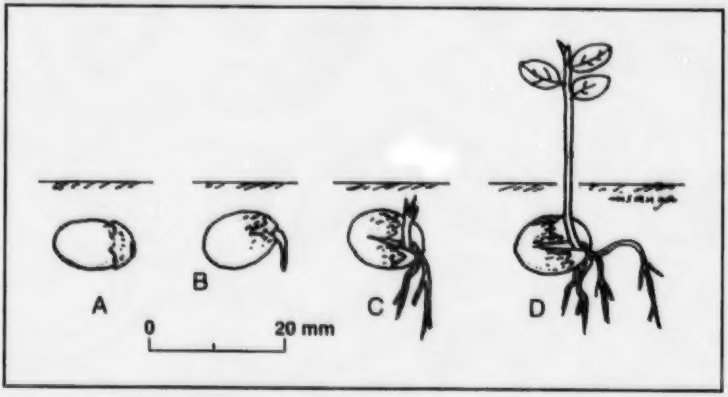


Figure 31. **Stages in seed germination and early development of *Agelaea pentagyna* seedlings. (A)** At sowing, **(B)** at 5 days, **(C)** at 10 days, **(D)** at 20 days.

Albizia anthelmintica Brongn.

LEGUMINOSAE: MIMOSOIDEAE

Other names

Worm-cure albizia; mpojoro (Kiswahili); olmkutani (Kimasai); mkutani (Kigogo).

Fruit morphology and seed extraction

The fruit is a thin, flat pod, green when young and straw-coloured when mature, about 7 cm long and 2 cm broad, and tapering at both ends. Each fruit contains three to five seeds. Dry pods are threshed in a gunny bag using a stick, and seeds are cleaned by shaking and winnowing. For large quantities a flailing thresher and an air-screen cleaner may be used (as for *Acacia nilotica*). About 20 kg of dry pods produce 1 kg of clean seeds.

Seed morphology

The seed is almost round but pointed at the scar end, flat, about 8 mm across, and straw coloured, with a thin and shiny seed coat. The flat surfaces are marked by a horseshoe-shaped line near the base. There are about 7500 seeds per kilogram.

Seed storage

The seed is orthodox and can be stored for two years at room temperature without significant loss of viability, if kept dry and free of insects.

Seed presowing treatment

The seed germinates well without pretreatment.

Seed germination

Germination is epigeal (Figure 32). The seed absorbs water and swells, then the seed coat ruptures and the radicle emerges. The hypocotyl elongates, and carries the cotyledons above the germination medium. The seed coat is either left inside the germination medium or carried up by the cotyledons until they unfold, when it falls off.

Germination is uniform and very good, reaching 80% after eight days and 95% after 10 days from sowing.

Plant uses

Liquid obtained from boiling the bark is very effective for combatting tapeworm and hookworms. The leaves are favoured by livestock.

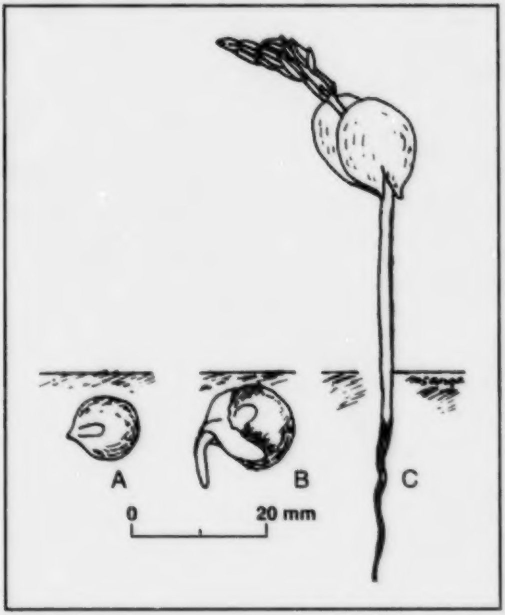


Figure 32. **Stages in seed germination and early development of *Albizia anthelmintica* seedlings. (A)** At sowing, **(B)** at 4 days, **(C)** at 7 days after sowing.

Albizia harveyi E. Fourn.

LEGUMINOSAE: MIMOSOIDEAE

Other names

Mkenge (Kiluguru).

Fruit morphology and seed extraction

The fruit is a flat pod, straw-coloured when mature, about 10 cm long and 2 cm broad, and tapering at both ends. Each pod contains up to seven seeds. Dry pods are threshed in a gunny bag using a stick, and seeds are cleaned by winnowing. About 15 kg of pods produce 1 kg of seeds.

Seed morphology

The seed is slightly elongated, flat, about 8 mm long and 5 mm broad, dark brown and compressed, with a hard seed coat. The flat faces have a horseshoe-shaped line near the base. There are about 9000 seeds per kilogram.

Seed storage

The seed is orthodox and can be stored for two years at room temperature without significant loss of viability, if kept dry and free of insects.

Seed presowing treatment

Seeds should be soaked in cold water for 12 hours before sowing.

Seed germination

Germination is epigeal (Figure 33). The seed absorbs water and swells. The seed coat ruptures at the base, and the radicle emerges. The hypocotyl elongates with slight bending and carries the cotyledons and seed coat above the germination medium. The seed coat later falls off after the cotyledons expand.

Germination is good and fairly uniform. It reaches 25% after 12 days and 65% after 21 days.

Plant uses

The timber is used for building and furniture making. Liquid obtained from boiling the roots is used as a component of a medicine for many intestinal troubles.

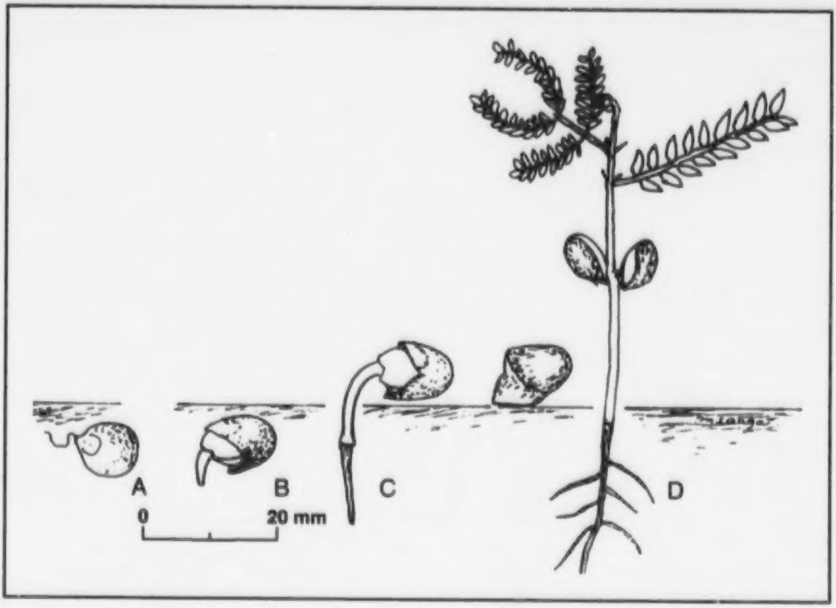


Figure 33. **Stages in seed germination and early development of *Albizia harveyi* seedlings. (A)** At sowing, **(B)** at 5 days, **(C)** at 10 days, **(D)** at 30 days after sowing.

Albizia lebbeck (L.) Benth.

LEGUMINOSAE: MIMOSOIDEAE

Other names

Woman's tongue; mkingu (Kiswahili).

Fruit morphology and seed extraction

The fruit is a large flat shiny pod, straw-coloured when mature, 20 cm long and 3 cm broad, rounded at the tip and sharp at the base (Figure 34). On average each pod contains seven seeds. Pods are persistent on the tree for a long time. The ripening pods are collected from the tree and drying is completed in the sun.

The pods are heaped on a tarpaulin or hessian sheeting material and beaten well with sticks to detach the seeds. The seeds are then cleaned by shaking and winnowing. For extraction of bulk quantities, a flailing thresher and an air-screen cleaner may be used (as for *Acacia nilotica*). About 12 kg of pods produce 1 kg of clean seeds.

Seed morphology

The seeds are flat, almost round, about 8 mm across, straw-coloured and compressed, with a hard seed coat. The flat faces are marked by a line parallel to the outline of the seed. There are about 7500 seeds per kilogram.

Seed storage

The seed is orthodox and can be stored for two years at room temperature without significant loss of viability, if kept dry and free of insects.

Seed presowing treatment

Small quantities may be pretreated using a hot wire. For bulk quantities, the seed gun may be used at a speed index which will give a crack percentage of about 12%. The hot water and boiling treatments are both appropriate (*see* section on presowing treatments); for the boiling treatment an immersion period of 60 seconds is recommended.

Seed germination

Germination is epigeal (Figure 35). The seed coat softens as the seed absorbs water. After about four or five days the seed coat ruptures and the radicle emerges through the scar end. The hypocotyl elongates, usually with slight bending, and carries the cotyledons above the germination medium. The seed coat splits and is either left inside the germination medium or is carried up, partly enclosing the cotyledons, until they unfold and the seed coat falls off. Cotyledons are sessile, and have small ear-like lobes at their base. The first two leaves are compound, and one is bipinnate with one pair of pinnae. Germination is very good, attaining 40% after 12 days and 80% after 22 days from sowing.

Plant uses

The tree is widely pollarded for fodder; leaves, twigs and young pods are fed to animals. The plant is used for nitrogen fixation, green manuring, and reforesting marginal sites. It is used in agroforestry systems to provide shade for coffee, tea and banana plants. The wood is used for furniture making, construction and firewood. *Albizia lebbeck* is a native of tropical Asia, but was introduced to Tanzania where it is now naturalised and planted throughout the country.

Figure 34. *Albizia lebbek* pods and seeds.

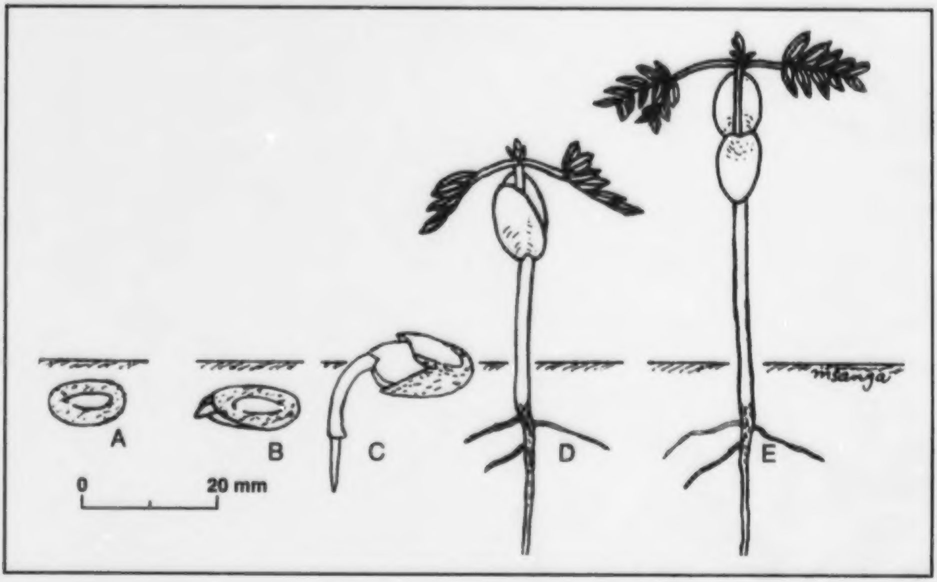


Figure 35. Stages in seed germination and early development of *Albizia lebbeck* seedlings. (A) At sowing, (B) at 5 days, (C) at 10 days, (D) at 15 days, (E) at 25 days after sowing.

Albizia petersiana (Bolle) Oliv.

LEGUMINOSAE: MIMOSOIDEAE

Other names

Many-stemmed albizia.

Fruit morphology and seed extraction

The fruit is a pod, about 17 cm long and 3 cm broad, deep reddish-purple to brown when ripe; each pod contains up to six seeds. Dry pods are threshed in a gunny sack, using a stick, and seeds are cleaned by shaking and winnowing. For larger quantities a flailing thresher and an air-screen cleaner may be used (as for *Acacia nilotica*). About 14 kg of dry pods produce 1 kg of clean seeds.

Seed morphology

The seed is almost round, flat, about 8 mm across, and straw-coloured with a hard seed coat. The flat surfaces are marked by a horseshoe-shaped line near the base. There are about 8000 seeds per kilogram.

Seed storage

The seed is orthodox and can be stored for three years at room temperature without significant loss of viability, if kept dry and free of insects.

Seed presowing treatment

Seeds should be soaked in cold water for six hours before sowing.

Seed germination

Germination is epigeal (Figure 36). The seed coat ruptures as the radicle emerges, and the hypocotyl elongates, carrying the cotyledons above the germination medium. The seed coat is either left inside the germination medium or carried up by the cotyledons until they unfold and it falls off.

Germination is good and uniform, attaining 40% after two weeks and 65% after three weeks from sowing.

Plant uses

The tree has a flat crown which provides good shade. The branches and stem are used for firewood and tool handles.

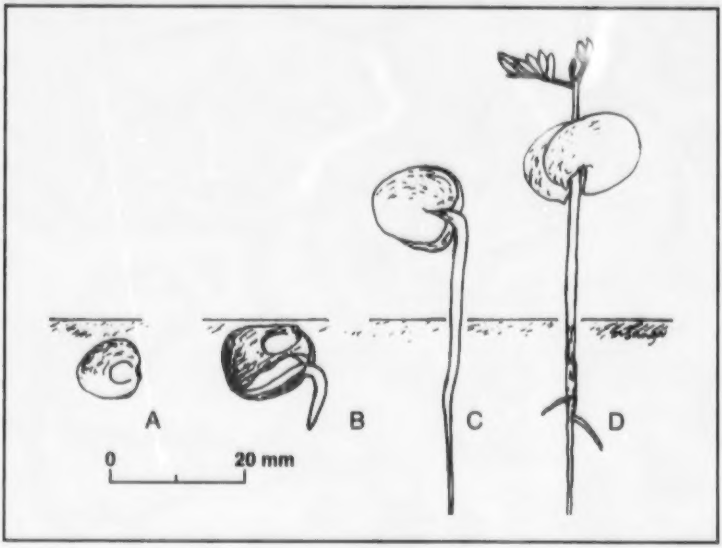


Figure 36. **Stages in seed germination and early development of *Albizia petersiana* seedlings. (A)** At sowing, **(B)** at 4 days, **(C)** at 10 days, **(D)** at 14 days after sowing.

Albizia schimperiana Oliv.

LEGUMINOSAE: MIMOSOIDEAE

Other names

Long-podded albizia; mririgwi, mreraiambo (Kipare); mshai (Kisambaa); mfuruanje (Kichaga); mkenge (Kiluguru).

Fruit morphology and seed extraction

The fruit is a flat reddish-brown pod, up to 30 cm long and 3 cm broad, containing up to five seeds. The ripening pods are collected from the tree and drying completed in the sun. To extract seeds, the pods are broken by hand or heaped on a tarpaulin and beaten with sticks; the seeds are then cleaned by shaking and winnowing. For extraction of bulk quantities of seeds a flailing thresher and an air-screen cleaner can be used (as for *Acacia nilotica*). About 14 kg of pods produce 1 kg of clean seeds.

Seed morphology

The seed is yellowish brown, smooth, thickest in the middle and narrowing towards both ends, compressed, with a hard seed coat, about 10 mm long and 6 mm broad. The flat faces have a yellowish, horseshoe-shaped line, or areole, near the base. The seeds vary in weight depending on collection locality, but on average there are about 10 000 seeds per kilogram.

Seed storage

The seed is orthodox and can be stored for two years at room temperature without significant loss of viability, if kept dry and free of insects.

Seed presowing treatment

Small quantities may be pretreated using a hot wire. For bulk quantities, the seed gun may be used at a speed index which will give a crack percentage of about 27%. The hot water treatment is also appropriate (*see* section on seed presowing treatments).

Seed germination

Germination is epigeal (Figure 37). The seed absorbs water and swells, and the seed coat ruptures at the scar end as the radicle emerges. The hypocotyl elongates and carries the cotyledons above the germination medium. The seed coat is either left inside the germination medium or carried up by the cotyledons until they unfold and it falls off. The cotyledons are sessile and have ear-like lobes at their bases. At first they change from white to green, but later become brown and shrivelled. The first leaf is compound with seven pairs of leaflets. Germination is good and fairly uniform, attaining 40% after 20 days and 70% after 30 days from sowing.

Plant uses

The tree is planted by the Wapare people of north-eastern Tanzania as a nurse tree in banana farms; this function translates into the Kipare name for the tree, "mreraiambo". It is also planted elsewhere for shade in banana and coffee farms.

The timber is used for building and furniture making. The wood is used for hoe handles, grain mortars, honey barrels and firewood. The bark is used traditionally as a cough remedy and as a wash for cleaning the finger nails. The pounded bark is rubbed on the breasts of a nursing woman to "clean" the milk and protect the baby from vomiting or diarrhoea.

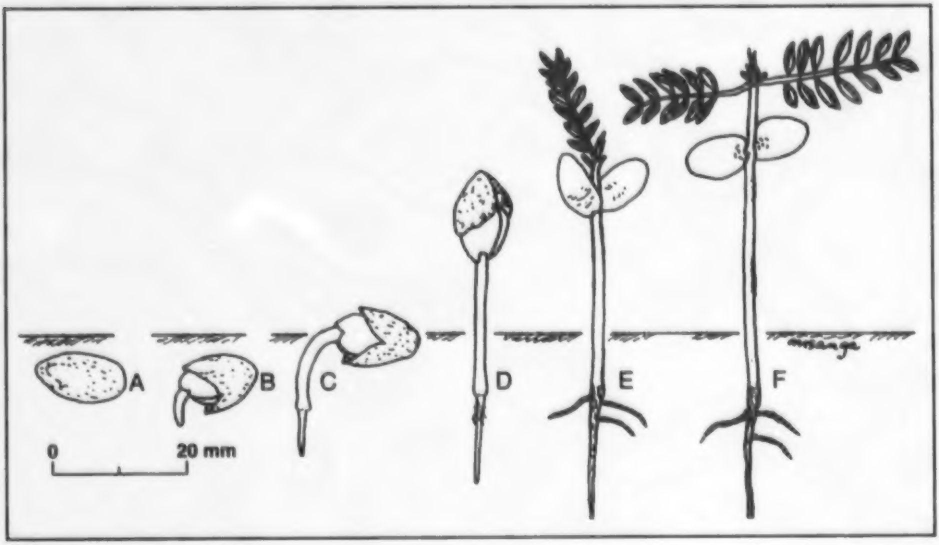


Figure 37. Stages in seed germination and early development of *Albizia schimperiana* seedlings. **(A)** At sowing, **(B)** at 5 days, **(C)** at 10 days, **(D)** at 15 days, **(E)** at 25 days, **(F)** at 30 days after sowing.

Albizia tanganyicensis Baker f.

LEGUMINOSAE: MIMOSOIDEAE

Other names

Paper bark albizia; mkingu (Kiswahili, Kisukuma, Kizigua).

Fruit morphology and seed extraction

The fruit is a flat pod, red-brown when mature, about 20 cm long and 3.5 cm broad, and tapering at both ends. Each fruit contains up to eight seeds. Dry pods are threshed in a gunny bag using a stick, and seeds are cleaned by shaking and winnowing. About 15 kg of dry pods produce 1 kg of clean seeds.

Seed morphology

The seed is almost round, flat, about 9 mm across, brown and shiny. The flat surfaces are marked by a horseshoe-shaped line near the base. There are about 7200 seeds per kilogram.

Seed storage

The seed is orthodox and can be stored for two years at room temperature without significant loss of viability, if kept dry and free of insects.

Seed presowing treatment

Seeds should be soaked in cold water for 12 hours before sowing.

Seed germination

Germination is epigeal (Figure 38). The seed absorbs water and swells enormously. The seed coat ruptures at the base as the radicle emerges. The hypocotyl elongates, bending slightly, and carries the cotyledons above the germination medium. The seed coat is either left inside the germination medium or carried up by the cotyledons until they unfold and it falls off.

Germination is very good; it reaches 40% after seven days and 80% after 10 days from sowing.

Plant uses

The wood is used for furniture making, construction and firewood.

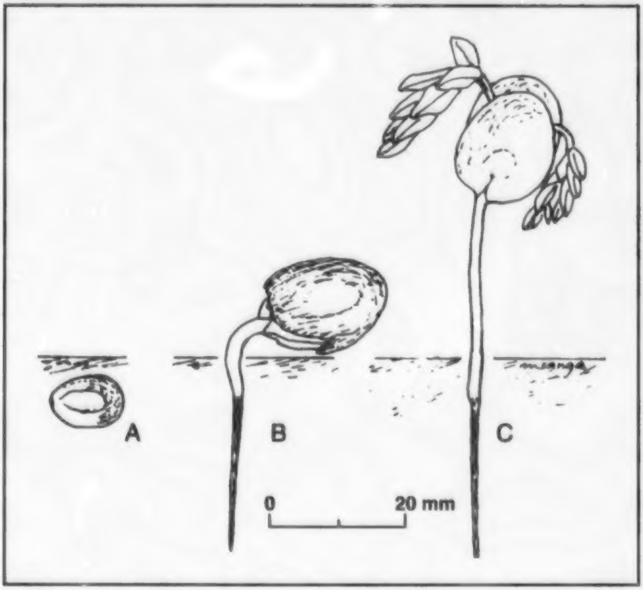


Figure 38. **Stages in seed germination and early development of *Albizia tanganyicensis* seedlings. (A)** At sowing, **(B)** at 3 days, **(C)** at 5 days after sowing.

Allanblackia stuhlmannii (Engl.) Engl.

GUTTIFERAE

Other names

Mkanye, mkimbo (Kiswahili); msani, msambu (Kisambaa, Kibondei); mkani (Kiluguru).

Fruit morphology and seed extraction

The fruit is a reddish brown capsule, cylindrical with rounded ends, 16–34 cm long and 15–17 cm wide. It weighs from 2.5 to 5.8 kg. This is the biggest true fruit of any indigenous tree in Tanzania. Each fruit contains 60–140 seeds. Ripe fruits are collected from the ground soon after falling, and are gently cracked to release the seeds. Fruit pulp remaining on the seed coat is removed by washing in water. The cleaned seeds are immersed in water and those which float are discarded, while seeds which sink are presumed to be viable and are retained. They are spread out on sheeting material in the shade for two days to allow surface water to evaporate. About 5 kg of fruits produce 1 kg of seed.

Seed morphology

The seed is brown, about 4 cm long and 3 cm wide, and has four blunt angles, one with a fleshy aril. The seed coat is brittle and streaked by strands of ducts resembling a network of fibres. There are about 100 seeds per kilogram.

Seed storage

The seed is recalcitrant and should be packed in small quantities (less than 10 kg) in cotton bags or gunny bags made of sisal or jute. Alternatively, seed can be kept in wire mesh trays under shade. Both methods provide adequate ventilation.

The seeds cannot tolerate desiccation below 20% moisture content and should not be stored at freezing temperatures. Seeds should be sown within four weeks after collection.

Seed presowing treatment

The seed does not require pretreatment, but the aril must be removed before sowing. The seed coat is easily broken and does not seem to play a significant role in germination. Pretreatment such as stratification has yet to be investigated.

Seed germination

Germination is hypogeal (Figure 39). When germination starts, one or more thin roots usually appear at the root pole. The epicotyl develops into to a stem covered with scales. The root may develop either before or after the stem, or not at all; in any case one or many adventitious roots soon differentiate at the stem base and grow rapidly to form the final root system.

Germination is slow and sporadic; about 80% of the seeds can be expected to germinate over a period of three to six months.

Plant uses

The seeds have a high market value. They are collected for both local consumption and for export, especially to Holland. The seed yields an edible fat used for cooking and lighting; it is also used as an ointment for pains in the limbs. The heartwood is suitable for furniture, while the sapwood is used for general construction and joinery. The tree is attractive and suitable for ornamental planting; a pleasant scent is given off by the large beautiful pink flowers.

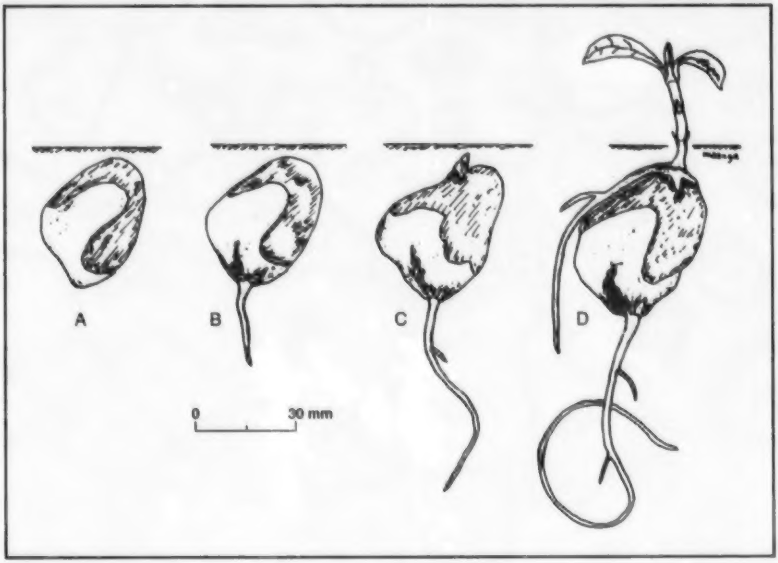


Figure 39. Stages in the germination of *Allanblackia stuhlmannii* seed. (A) At sowing, (B) at 8 weeks, (C) at 12 weeks, (D) at 20 weeks after sowing.

Anthocleista grandiflora Gilg
Syn. *Anthocleista zambesiaca* Baker
LOGANIACEAE

Other names

Cabbage tree; irato (Kipare).

Fruit morphology and seed extraction

The fruit is almost spherical, fleshy and smooth, and turns brown on maturity. It is up to 3.5 cm long and 2 cm broad. Each fruit has many minute seeds. The fruits are squashed by hand to squeeze the seeds out of the pulp. The pulp, fruit skin and empty seeds float and are poured off together with the water, leaving clean viable seeds at the bottom. About 40 kg of fruits produce 1 kg of seeds.

Seed morphology

The seed is very small, spherical, about 1.5 mm across, and has a thin red seed coat. There are about 400 000 seeds per kilogram.

Seed storage

Seeds should be kept in a cool, dry place, and should be sown within one year after collection. The seed is intermediate between orthodox and recalcitrant.

Seed presowing treatment

The seed does not need any pretreatment.

Seed germination

Germination is epigeal (Figure 40). The radicle protrudes and descends, and the hypocotyl elongates and carries the seed coat up on the cotyledons. Later the seed coat falls off as the leafy cotyledons enlarge.

Germination is good but sporadic. It attains 20% after two weeks and 60% after four weeks from sowing.

Plant uses

A boiled decoction of the leaves is used as a remedy for malaria, and the bark is chewed to relieve diarrhoea. The tree has big shiny leaves, and has potential as an ornamental in high- and mid-elevation zones.

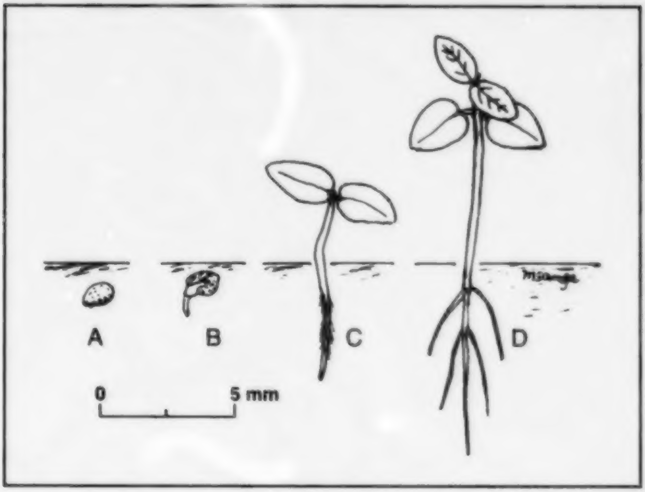


Figure 40. **Stages in seed germination and early development of *Anthocleista grandiflora* seedlings. (A)** At sowing, **(B)** at 10 days, **(C)** at 15 days, **(D)** at 25 days after sowing.

Antiaris toxicaria (Pers.) Lesch.

MORACEAE

Other names

Upas tree, false mvule; mkomba (Kipare); mkunde (Kiswahili).

Fruit morphology and seed extraction

The fruit is an egg-shaped single-seeded drupe, about 1.5 cm long, and red when ripe. The fruit skin is removed by macerating in water and then squashing by hand; the seeds are cleaned by washing in water. About 5 kg of fruits produce 1 kg of seeds.

Seed morphology

The seed is almost spherical, light brown, and about 1.2 cm in diameter, with a brittle seed coat. There are about 1500 seeds per kilogram.

Seed storage

The seed is recalcitrant, and should not be dried in the sun or stored at freezing temperatures. Seed should be sown within six weeks of collection.

Seed presowing treatment

The seed does not need any pretreatment.

Seed germination

Germination is hypogeal (Figure 41). The thick radicle emerges at the scar end. The cotyledonary stalks elongate, and the epicotyl emerges between them. The cotyledons and seed coat remain in the germination medium, attached to the seedling.

When fresh seeds are used, germination is very good and moderately uniform. It reaches 10% after two weeks and 80% after four weeks from sowing.

Plant uses

The wood is soft and is used for plywood. The fruits are much liked by birds and monkeys.

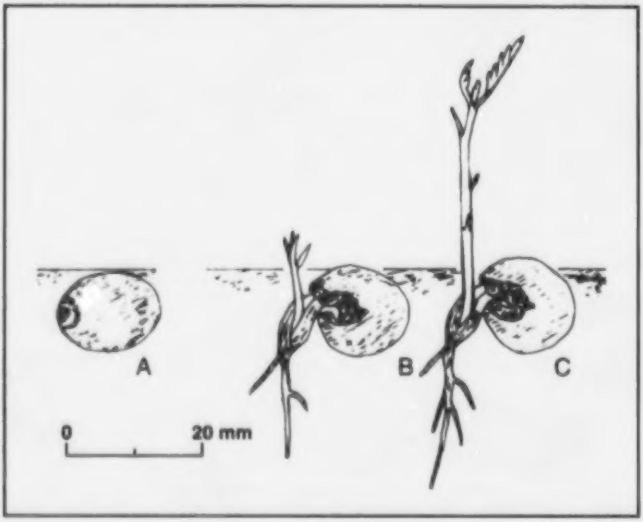


Figure 41. **Stages in seed germination and early development of *Antiaris toxicaria* seedlings. (A)** At sowing, **(B)** at 15 days, **(C)** at 20 days after sowing.

Azanza garckeana (F. Hoffm.) Exell & Hillc.

Syn. *Thespesia garckeana* F. Hoffm.

MALVACEAE

Other names

African chewing gum; mtakataka (Kipare); mtoyo (Kigogo); motovo (Kinyamwezi); mtowo (Kihehe); mtogo (Kinyiramba).

Fruit morphology and seed extraction

The fruit is round, woody, yellow-brown, hairy, and 2–8 cm in diameter; it contains many seeds. There are four or five fruit parts, which are split open by hand to release the seeds. About 10 kg of fruits produce 1 kg of seeds.

Seed morphology

The seed has an irregular shape but is less pointed at the scar end. It is about 5 mm in diameter and covered with wool-like tufts of hair. There are about 4000 seeds per kilogram.

Seed storage

The seed remains viable for up to six months at room temperature. It is thought to be intermediate between orthodox and recalcitrant.

Seed presowing treatment

The seed does not need any pretreatment.

Seed germination

Germination is epigeal (Figure 42). The radicle protrudes at the scar point and develops into a taproot. The hypocotyl elongates, bending slightly, while carrying the seed coat on the cotyledons. The leafy cotyledons expand greatly, split apart, and change colour from white to green.

Germination is very good and uniform. It reaches 40% after 15 days and 80% after 20 days from sowing.

Plant uses

The fruit is sweet and is used as a natural chewing gum. The tree provides firewood, tool handles, bark fibre, and bee forage.

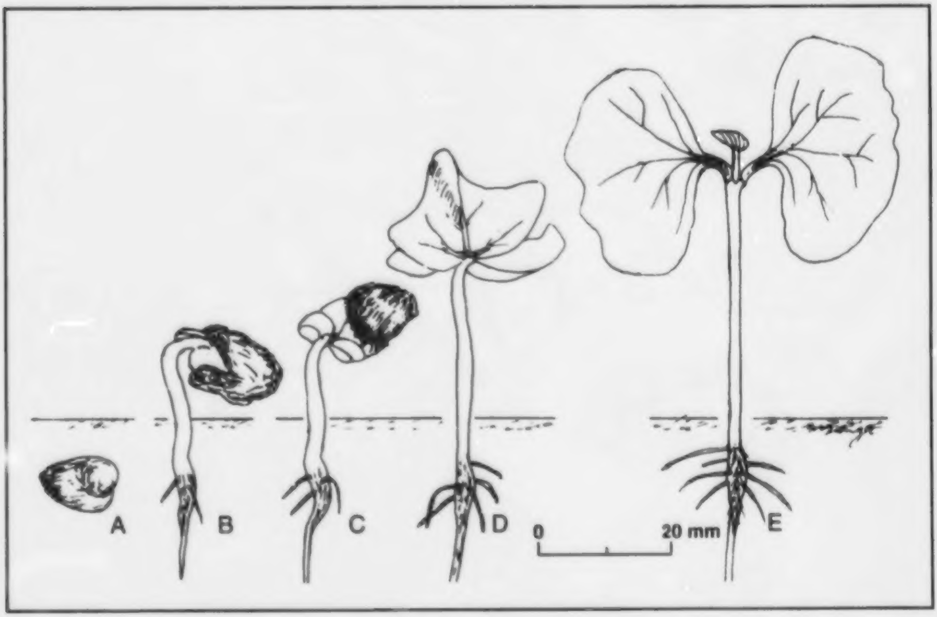


Figure 42. **Stages in seed germination and early development of *Azanza garckeana* seedlings.** (A) At sowing, (B) at 7 days, (C) at 8 days, (D) at 15 days, (E) at 18 days after sowing.

***Balanites aegyptiaca* (L.) Delile**
BALANITACEAE

Other names

Desert date; mkizingo, mkonga (Kipare); ol-ngoswa (Kimasai); mwamba ngoma (Kiswahili).

Fruit morphology and seed extraction

The fruit is green at first, turning yellow as it ripens; it tapers at both ends, and contains a large, hard stone surrounded by yellow-brown sticky flesh. In the ripe fruit, there is a space between the flesh and the thin leathery wrinkled skin. The skin and pulp are scraped from the stone with a knife, or by using a mortar and pestle, and the stones washed in water. About 5 kg of fruit produce 1 kg of seeds.

Seed morphology

The seed is contained in a large hard stone, which is pointed and tapering at both ends; it is about 2.5 cm long and 1.3 cm broad. There are about 800 stones per kilogram.

Seed storage

The seed is orthodox and can be stored for three years at room temperature without significant loss of viability, if kept dry and free of insects.

Seed presowing treatment

The stones should be soaked in tap water for 12 hours. For small samples, stones may be cracked using a small hammer or a table vice and the seeds removed completely from the shell. Each stone contains one seed.

Seed germination

Germination is intermediate between hypogeal and epigeal (Figure 43). The cotyledons enlarge and cause the seed coat to burst at the scar end. The radicle protrudes through the scar and elongates greatly to form a stout taproot. The hypocotyl is very short and the cotyledons remain partly below the surface of the germination medium. Later the cotyledons unfold as the epicotyl develops.

Germination is good and moderately uniform, attaining 10% after two weeks and 70% after four weeks from sowing.

Plant uses

The fruit pulp and kernel are edible. Fruits are also used to feed goats in dry areas. The wood makes excellent tool-handles. The stem and branches make excellent firewood which burns without smoke.

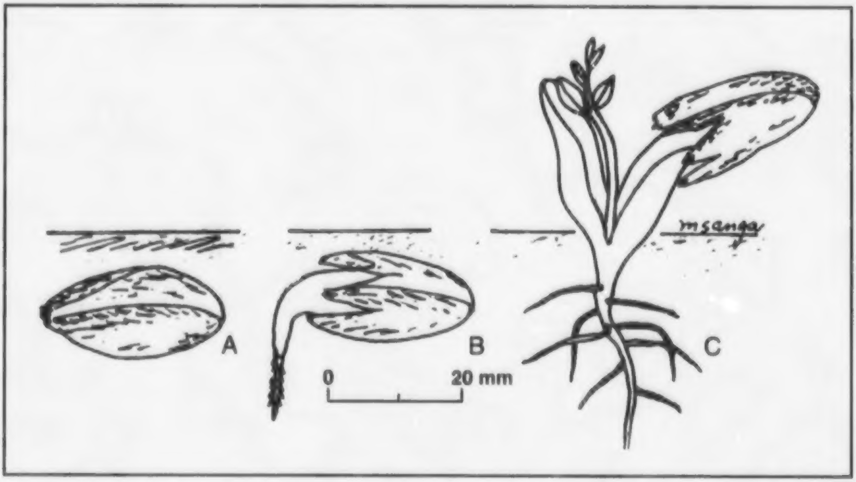

A
B
C
0
20 mm
msanga

Figure 43. **Stages in seed germination and early development of** ***Balanites aegyptiaca*** **seedlings. (A)** At sowing, **(B)** at 10 days, **(C)** at 14 days after sowing.

Baphia kirkii Baker

LEGUMINOSAE: PAPILIONOIDEAE

Other names

Mkuruti (Kiswahili); mkarakanga (Kizigua).

Fruit morphology and seed extraction

The pods are about 12 cm long and 4 cm wide, somewhat woody, and yellowish brown. Ripe pods are collected from trees and drying is completed in the sun; pods are opened by hand to release seeds. Alternatively, seeds may be collected from the ground soon after natural shedding. About 10 kg of fruit produce 1 kg of seeds.

Seed morphology

The seed is almost egg-shaped, convex on both sides, and about 1.7 cm long and 1.2 cm broad; it is dark brown with a hard seed coat and a prominent white scar. There are about 1000 seeds per kilogram.

Seed storage

The seed is orthodox and can be stored for three years at room temperature without significant loss of viability if kept dry and free of insects.

Seed presowing treatment

The seed does not require pretreatment before sowing.

Seed germination

Germination is epigeal (Figure 44). The seed coat softens as the seed absorbs water. The cotyledons swell greatly and rupture the seed coat, and the radicle emerges and develops into a taproot. The hypocotyl elongates, bending slightly, and rises above the germination medium. The seed coat is usually left in the germination medium but is sometimes carried up with the cotyledons.

Germination is good and moderately uniform, reaching 25% after 15 days and 80% after 30 days from sowing.

Plant uses

The timber is good for furniture, flooring, turnery, and boat building. The stem and branches are used for charcoal and hut building. The tree is attractive and suitable for planting as an avenue tree due to its sweet-scented, beautiful, yellow-spotted, white flowers.

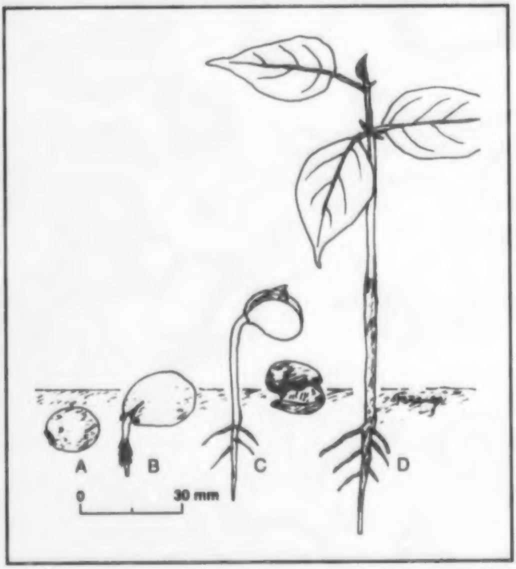


Figure 44. **Stages in seed germination and early development of *Baphia kirkii* seedlings.** **(A)** At sowing, **(B)** at 10 days, **(C)** at 20 days, **(D)** at 60 days after sowing.

Bauhinia petersiana Bolle

LEGUMINOSAE: CAESALPINIOIDEAE

Other names

White bauhinia; mgobwali (Kiswahili); mkomba (Kihehe); mfumbi, mnoga (Kinyamwezi); mzunguzungu (Kiluguru).

Fruit morphology and seed extraction

The fruit is a large, brown, smooth, woody pod, up to 18 cm long and 7 cm wide, which splits explosively when mature. Each pod contains five to eight seeds. Pods are threshed in a gunny bag using a stick, and seeds are cleaned by shaking and winnowing. About 8 kg of fruit produce 1 kg of seeds.

Seed morphology

The seed is shiny, brown-purple, large, and up to 2 cm long and 1.5 cm broad. There are about 1500 seeds per kilogram.

Seed storage

The seed is orthodox but, because of its high oil content, should be kept in a cool dry place. Seed should be sown within six months of collection.

Seed presowing treatment

Seed should be soaked in cold water for 12 hours.

Seed germination

Germination is intermediate between epigeal and hypogeal (Figure 45). The seed absorbs water and swells greatly. The radicle emerges from the scar side and develops into a vigorous taproot. The cotyledons unfold and give way to the developing epicotyl. The hypocotyl is very short, and the cotyledons and seed coat remain partly buried beneath the surface of the germination medium.

Germination is good and moderately uniform, reaching 25% after three weeks and 70% after five weeks from sowing.

Plant uses

The seeds are roasted and eaten during times of famine. The tree can be planted as an ornamental and produces large, beautiful, white, scented flowers.

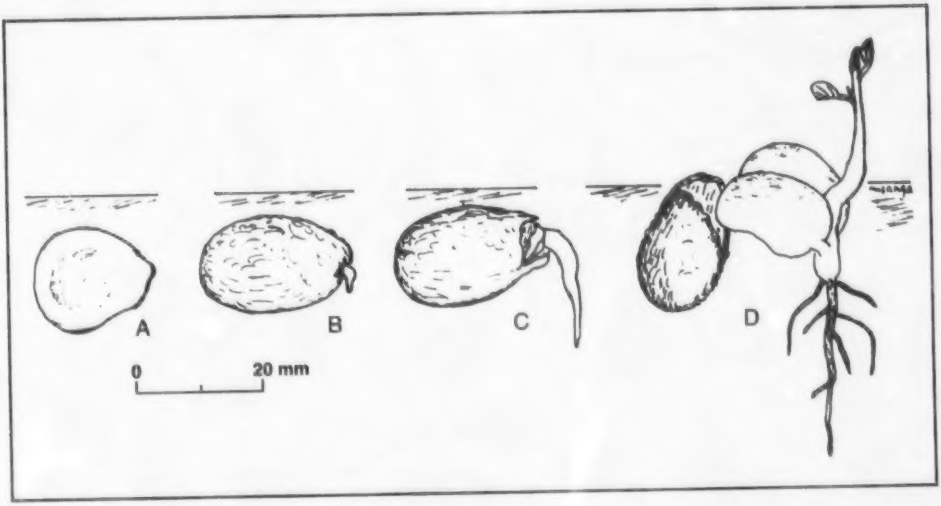


Figure 45. **Stages in seed germination and early development of *Bauhinia petersiana* seedlings.** **(A)** At sowing, **(B)** at 4 days, **(C)** at 5 days, **(D)** at 20 days after sowing.

***Bauhinia thonningii* Schumach.**

Syn. *Piliostigma thonningii* (Schumach.) Milne-Redh.

LEGUMINOSAE: CAESALPINIOIDEAE

Other names

Camel's foot leaf tree; msaponi (Kiswahili).

Fruit morphology and seed extraction

The fruit is an elongated pod, usually 18 cm long, 5 cm broad and 1.5 cm thick, and brown when mature (Figure 46). Each fruit contains up to seven seeds. The fruit does not break open, and remains on the tree for a long time. Dry pods are broken into pieces by hand, and seeds are extracted by pounding the broken pieces in a mortar. About 10 kg of pods produce 1 kg of seeds.

Seed morphology

The seed is almost round to egg-shaped, somewhat compressed, and has a hard, dark brown seed coat. Seed are about 9 cm long and 5 cm broad. There are about 7000 seeds per kilogram.

Seed storage

The seed is orthodox and can be stored for up to five years at room temperature without significant loss of viability, if kept dry and free of insects.

Seed presowing treatment

Small quantities may be pretreated using a hot wire; when large quantities are to be pretreated, the hot water treatment should be used (*see* section on seed presowing treatments).

Seed germination

Germination is epigeal (Figure 47). The seed coat takes up water and becomes swollen and mucilaginous. The radicle emerges from the scar end, then the hypocotyl elongates and carries the cotyledons above the germination medium. The seed coat is either left within the germination medium or carried up by the cotyledons until they unfold and it falls off.

Germination is very good and uniform, attaining 50% after 12 days and 80% after 16 days from sowing.

Plant uses

Extracts of the pods, seeds and roots are used as dye; the colours vary from red-brown to dark blue or even black. The wood is used as fuel. The fruit pulp is edible.

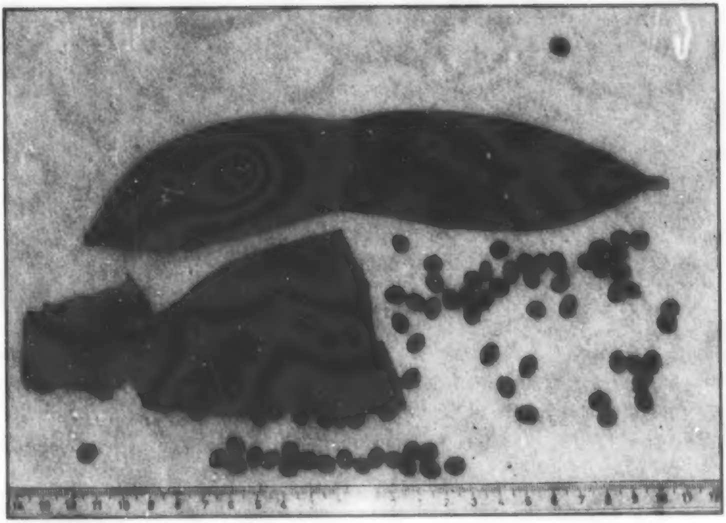


Figure 46. ***Bauhinia thonningii*** **pods and seeds.**

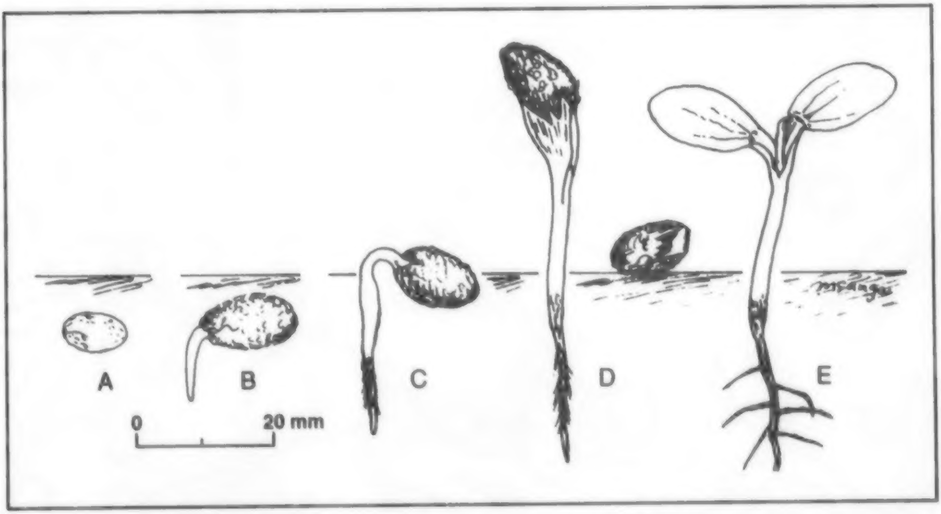


Figure 47. Stages in seed germination and early development of *Bauhinia thonningii* seedlings.
(A) At sowing, **(B)** at 6 days, **(C)** at 8 days, **(D)** at 12 days, **(E)** at 14 days after sowing.

Beilschmiedia kweo (Mildbr.) Robyns & R. Wilczek

Syn. *Tylostemon kweo* Mildbr.

LAURACEAE

Other names

Mfimbo, mkweo (Kisambaa).

Fruit morphology and seed extraction

The fruit is almost egg-shaped, about 6 cm long and 3 cm broad, with a fleshy pericarp. After ripening, the fruit splits, liberating one seed. Ripe fruits are collected from the trees and opened with a knife to release the seed. Alternatively, clean seeds may be collected from the ground soon after natural shedding. About 2 kg of fruit produce 1 kg of seed.

Seed morphology

The seed is egg-shaped, about 4.5 cm long and 2.5 cm broad, and is light green with a brittle seed coat. The embryo axis is buried in a groove between two large cotyledons. There are about 45 seeds per kilogram.

Seed storage

The seed is recalcitrant and should be packed in small quantities (less than 10 kg) in cotton bags or in gunny bags made of sisal or jute. Alternatively, they can be kept in wire mesh trays under shade. Both methods provide good ventilation.

The seeds cannot tolerate desiccation below a moisture content of 20% and should not be stored at freezing temperatures. Seeds should be sown within two months of collection.

Seed presowing treatment

The seed does not require any pretreatment, but, owing to the long germination period, other pretreatments such as stratification should be investigated.

Seed germination

Germination is hypogeal (Figure 48). First, the radicle elongates and emerges through the scar. The cotyledons expand and split the seed coat along the line between them. The cotyledonary stalks elongate, and the epicotyl emerges between the stalks and breaks through the seed coat. The base of the epicotyl is enclosed by a short sheath formed by the joined bases of the stalks. The cotyledons are left within the seed coat, buried in the germination medium.

Germination is good but sporadic, generally reaching 12% after two months and 70% after three months from sowing.

Plant uses

The timber is used for furniture, flooring and gun stocks, and branches are used for making grain mortars and tool handles. *Beilschmiedia kweo* is endemic in the Usambara mountains in north-eastern Tanzania, and is an important climax species for water catchment planting in those areas.

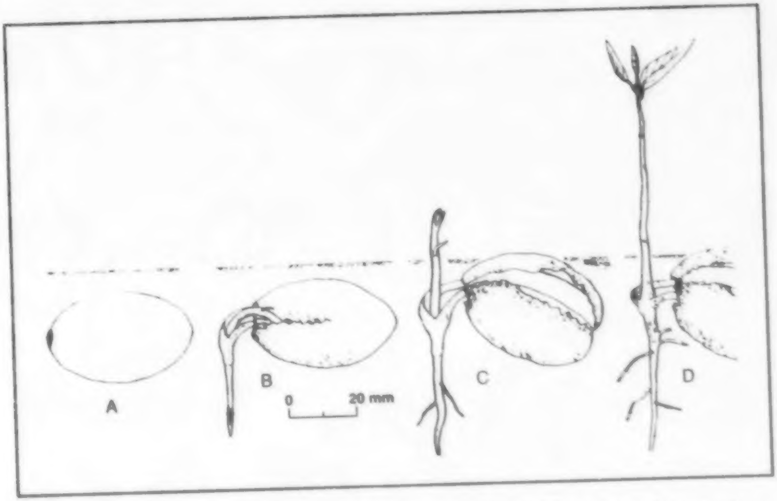


Figure 48. Stages in the germination of *Beilschmiedia kweo* seed. (A) At sowing, **(B)** at 6 weeks, **(C)** at 7 weeks, **(D)** at 12 weeks after sowing.

Berchemia discolor (Klotzsch) Hemsl.

Syn. *Phyllogeiton discolor* (Klotzsch) Herzog

RHAMNACEAE

Other names

Bird plum, wild almond; mnago (Kiswahili); mkuni (Kinyamwezi); mnyahumbu (Kiluguru, Kipogoro); mgandu (Kigogo); okoo (Kisandawi).

Fruit morphology and seed extraction

The fruit is a fleshy, yellow egg-shaped drupe, about 2 cm long and 1 cm in diameter, containing one seed. Ripe fruits are macerated in water for 12 hours then squashed by hand to remove the skin and pulp around the seeds. The pulp and skin float and can be poured off with the water, leaving clean viable seeds at the bottom.

Seed morphology

The seed is shiny, light brown, slightly compressed and almost pear-shaped, with a hard seed coat. It is about 1 cm long and 0.5 cm broad. There are about 10 000 seeds per kilogram.

Seed storage

The seed is orthodox and can be stored for up to two years at room temperature without significant loss of viability, if kept dry and free of insects.

Seed presowing treatment

Part of the seed coat at the scar end should be cut off using a sharp knife or abraded with a file. Care should be exercised to make sure that the cut is not so deep as to injure the radicle. At this stage the end of the seed will be more or less wedge-shaped. After this the seed should be soaked in cold water for 12 hours and then sown immediately.

Seed germination

Germination is epigeal (Figure 49). The radicle emerges first, then the hypocotyl elongates vigorously, bending greatly, and rises above the germination medium together with the cotyledons. The hypocotyl is somewhat swollen from the root collar up to the bend. On exposure to light, the cotyledons change from white to green and unfold to reveal the developing primary leaves.

Germination is good but sporadic. When the seed is pretreated by nicking and soaking in water, germination reaches 30% after 6 weeks and 65% after 10 weeks from sowing.

Plant uses

The fruit is edible. The wood is yellow-brown and hard with an attractive short grain; it is good for furniture construction.

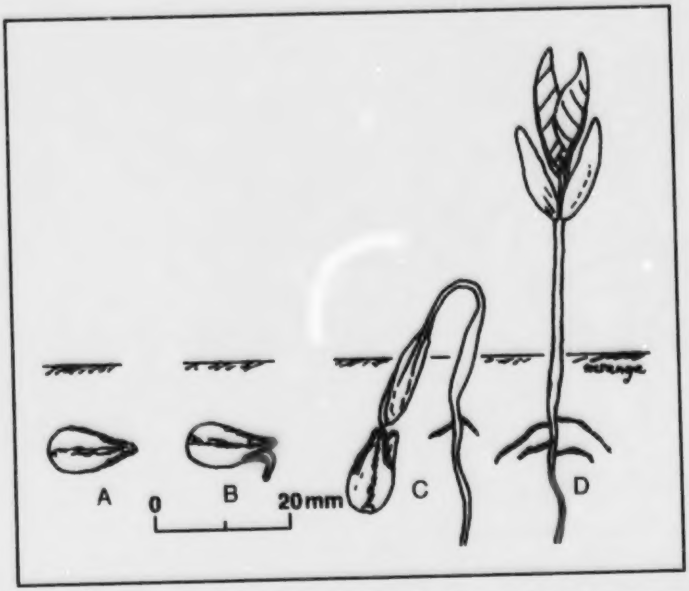


Figure 49. Stages in seed germination and early development of *Berchemia discolor* seedlings. (A) At sowing, (B) at 4 weeks, (C) at 5 weeks, (D) at 6 weeks after sowing.

Bersama abyssinica Fresen.
MELIANTHACEAE

Other names

Mranguwe, mrindawa (Kichaga); mbasamono (Kihehe); mtumbati, mbamba (Kisambaa); ikochokocho (Kirangi); wamis (Iraqw).

Fruit morphology and seed extraction

The fruit is a pale green capsule, about 2.5 cm in diameter, and densely covered with short, soft hairs which disappear when the fruit is ripe. The ripe fruits are collected from standing trees and after-ripened in the shade for two to three days. The fruit wall splits into four parts, each containing one seed. Seeds are removed from the fruit by hand or by shaking. About 4 kg of fruit produce 1 kg of seed.

Seed morphology

The seed is egg shaped, about 15 mm long and 9 mm broad, and is bright red with a yellow cup-shaped aril covering the base. There are about 1200 seeds per kilogram.

Seed storage

The seed is recalcitrant and should be packed in small quantities (less than 5 kg) in cotton bags or in gunny bags made of sisal or jute fibre. Alternatively, they can be kept in wire mesh trays under shade. Both methods provide good ventilation.

The seeds cannot tolerate desiccation below 20% moisture content and should not be stored at freezing temperatures. Seeds should be sown within four weeks following collection.

Seed presowing treatment

The aril must be removed. The seed coat is thin and does not seem to play a significant role in germination. The prolonged germination period suggests that other pretreatments, such as warm stratification, should be investigated.

Seed germination

Germination is epigeal (Figure 50). The radicle emerges through the scar and pushes its way downwards, while the hypocotyl elongates and carries the cotyledons, enclosed within the seed coat, above the germination medium. The first leaves then emerge from the seed coat and unfold. The split seed coat eventually falls off.

Germination is good but sporadic. It reaches 45% after seven weeks and 70% after 10 weeks from sowing day.

Plant uses

Liquid obtained from boiled bark is used as an anthelmintic and as a purgative. The trunks of many trees show scars where the bark has been peeled off for use as human medicine. The leaves and shoots are pounded together and used as an insecticide to control shoot borer in maize. The wood is used in making plywood and spoons. The seeds can be substituted for *Trichilia emetica* seeds in making soap.

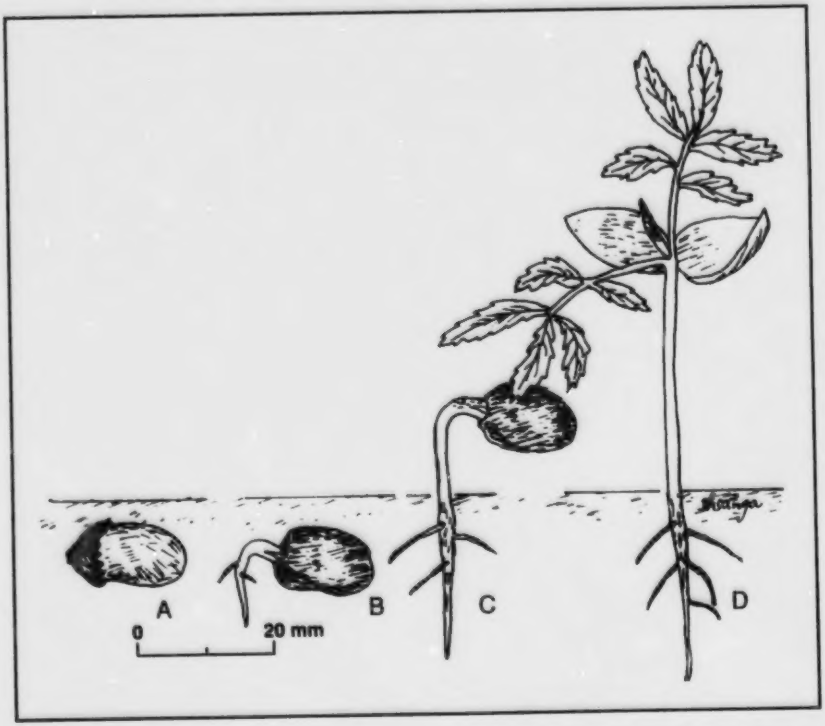


Figure 50. **Stages in seed germination and early development of *Bersama abyssinica* seedlings. (A)** At sowing, **(B)** at 30 days, **(C)** at 40 days, **(D)** at 60 days after sowing.

Bombax rhodognaphalon K. Schum.
BOMBACACEAE

Other names

Kapok tree; mkaranga mti (Kiswahili, Kinyakysa); mgude (Kiluguru).

Fruit morphology and seed extraction

The fruit is a brown woody capsule, about 6 cm long and 3 cm broad, thickest in the middle and narrowing towards both ends. When dry it splits open, releasing many seeds in red-brown kapok. About 16 kg of fruits produce 1 kg of seeds.

Seed morphology

The seed is pointed on the scar end and rounded on the opposite side, about 10 mm long and 8 mm broad, with a brown, rough seed coat; it is light in weight for its size. There are about 3000 seeds per kilogram.

Seed storage

Seeds should be kept in a cool (2–5°C) dry place. Where such conditions are not available, seeds can be kept at ambient air temperature but out of direct sunshine. Seeds are intermediate between orthodox and recalcitrant, and should be sown within three months after collection.

Seed presowing treatment

The seed does not require any pretreatment.

Seed germination

Germination is epigeal (Figure 51). The seed coat cracks and the radicle protrudes at the scar end. The seed coat is carried up by the hypocotyl on the cotyledons. The leafy cotyledons expand greatly, and change colour from white to green.

Germination is very good and uniform. It reaches 40% after 10 days and 90% after 15 days from sowing day.

Plant uses

The wood is used for plywood, the seed is edible, and the bark produces fibre and a reddish-brown dye. The fruit produces a red-brown kapok used for stuffing cushions.

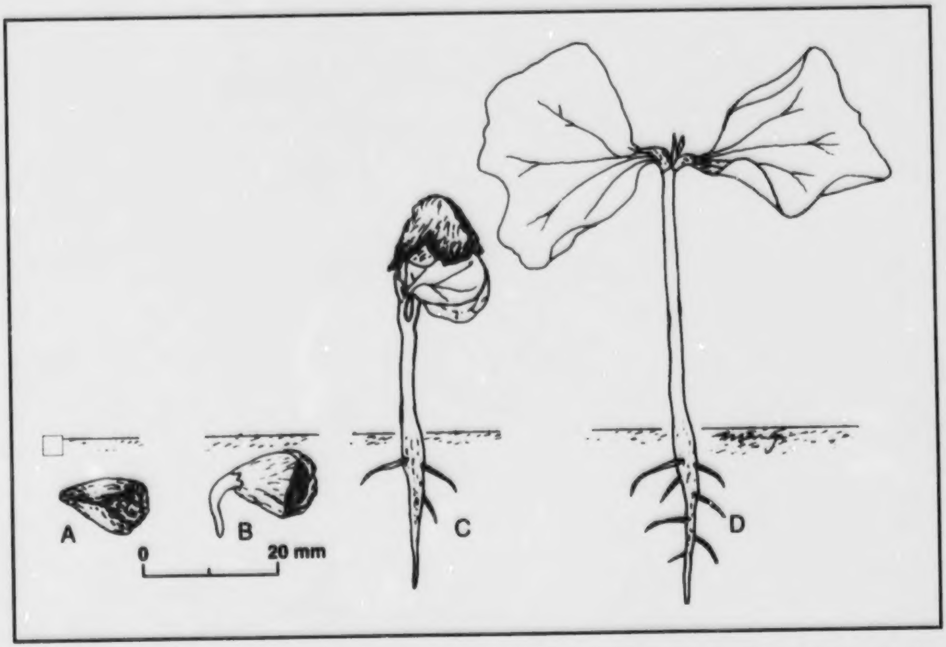


Figure 51. Stages in seed germination and early development of *Bombax rhodognaphalon* seedlings. (A) At sowing, (B) at 4 days, (C) at 8 days, (D) at 12 days after sowing.

Boscia salicifolia Oliv.

CAPPARACEAE

Other names

Willow-leaved boscia; mtumba (Kigogo); mkuruka (Kiluguru, Kizaramo); mvuti, mkuluka (Kinyamwezi); Muenje-enje (Kipare).

Fruit morphology and seed extraction

The fruit is round, up to 2 cm across, smooth, and yellow when ripe; it contains one seed. The pulp is removed by macerating the fruit in water and then squashing by hand. The seeds are cleaned by washing in water. The pulp, skin and seeds which float on the surface are discarded. Seeds which sink to the bottom are retained as viable, and are dried in the shade for one day. About 10 kg of fruits produce 1 kg of seeds.

Seed morphology

The seed is kidney-shaped with rounded tips, and has a rough, brittle, white seed coat; it is about 12 mm long and 8 mm broad. There are about 4000 seeds per kilogram.

Seed storage

The seed is recalcitrant and should be packed in small quantities (less than 5 kg) in cotton bags to provide good ventilation. Seed should be stored at room temperature and sown within four weeks of collection.

Seed presowing treatment

The seed does not require pretreatment before sowing.

Seed germination

Germination is epigeal (Figure 52). The seed coat cracks and the radicle protrudes at the scar end. The seed coat is carried up on two leafy cotyledons by the hypocotyl. The cotyledons unfold, expand greatly and change colour from white to green.

Germination is very good and uniform with fresh seeds. It reaches 35% after 10 days and 90% after 15 days from sowing.

Plant uses

The tree is suitable for planting in avenues and for shade, particularly in dry areas. The stem is used for building poles and firewood. The leaves provide fodder for goats.

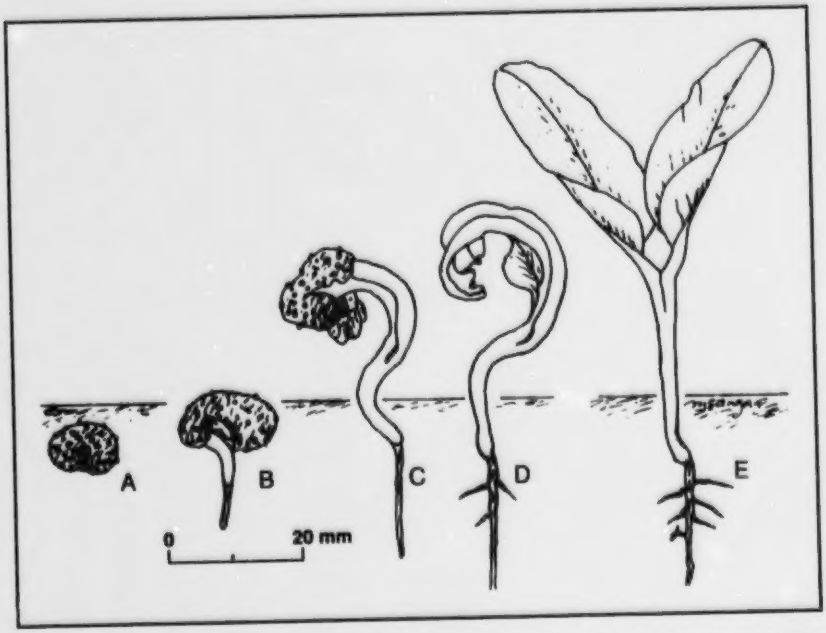


Figure 52. Stages in seed germination and early development of *Boscia salicifolia* seedlings. (A) At sowing, (B) at 5 days, (C) at 8 days, (D) at 10 days, (E) at 14 days after sowing.

Brachystegia spiciformis Benth.

LEGUMINOSAE: CAESALPINIOIDEAE

Other names

Bean-pod tree; myombo, mriti (Kiswahili); mtundu (Kinyamwezi); mkwe (Kihehe).

Fruit morphology and seed extraction

The fruit is a flat, dark brown pod, to 14 cm long. When dry it splits explosively, scattering four to six seeds. About 5 kg of fruits produce 1 kg of seeds.

Seed morphology

The seed is brown, slightly elongated, with blunt angles, and flattened, about 1.8 cm long and 1.3 cm wide. There are about 2000 seeds per kilogram.

Seed storage

The seed is orthodox, and, properly dried, can be stored at room temperature for one year without significant loss in viability.

Seed presowing treatment

The seed does not require any pretreatment. However, soaking the seeds in cold water for six hours hastens the germination process.

Seed germination

Germination is epigeal (Figure 53). It commences with bursting of the seed coat. The radicle emerges and develops into a taproot. The hypocotyl elongates and carries the cotyledons, together with the seed coat, above the germination medium. The first leaves and the young shoot push their way up between the cotyledons.

Germination is very good and uniform. It reaches 50% after 12 days and 98% after 20 days from sowing.

Plant uses

The tree is useful for firewood, charcoal, timber, and shade. The bark produces fibre used for ropes and also is boiled to extract a brown pigment used for dyeing mats. The flowers are important for bee forage.

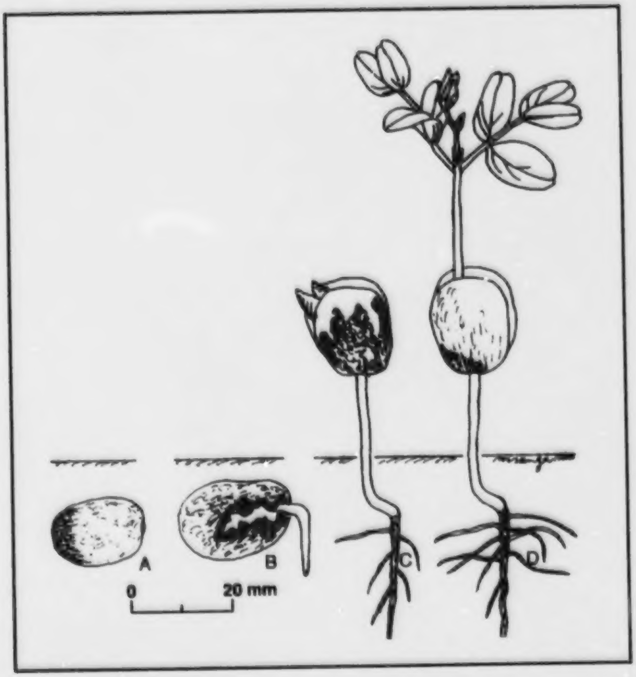


Figure 53. **Stages in seed germination and early development of *Brachystegia spiciformis* seedlings.** (A) At sowing, (B) at 7 days, (C) at 12 days, (D) at 20 days after sowing.

Brackenridgea zanguebarica Oliv.

OCHNACEAE

Other names

Msonga mahana (Kiswahili, Kidigo).

Fruit morphology and seed extraction

The fruit is a small egg-shaped drupe, about 1.6 cm long and 1.2 cm broad, turning red to black when ripe. The seed is extracted by macerating the fruit in water and squashing it by hand. Seeds are then cleaned by washing in water; skin, pulp and empty seeds float, and can be poured off and discarded. About 4 kg of fruits produce 1 kg of seeds.

Seed morphology

The seed is small and egg-shaped, about 1 cm long and 0.7 cm broad, and covered with a thin leathery brown seed coat. There are about 4000 seeds per kilogram.

Seed storage

The seed is orthodox and can retain viability for up to one year at room temperature.

Seed presowing treatment

It is not known which pretreatment would be effective, although it appears likely that pretreatment would improve germination speed.

Seed germination

Germination is hypogeal (Figure 54). It commences with the emergence of a fine radicle at the scar end. The cotyledonary stalks elongate, and the epicotyl pushes up between them. The cotyledons are left within the seed coat and remain in the germination medium, attached to the seedling.

Germination is fair but delayed. It reaches 20% after 10 weeks and 45% after 14 weeks from sowing.

Plant uses

The bark is boiled in water to provide a yellow dye for materials used in weaving mats and baskets. Pieces of cloth may be dyed in their entirety or in patterns by protecting areas by mixing or covering with plastic. Mats and baskets are made out of palm leaflets *(Phoenix reclinata)* which are dried and trimmed before dyeing.

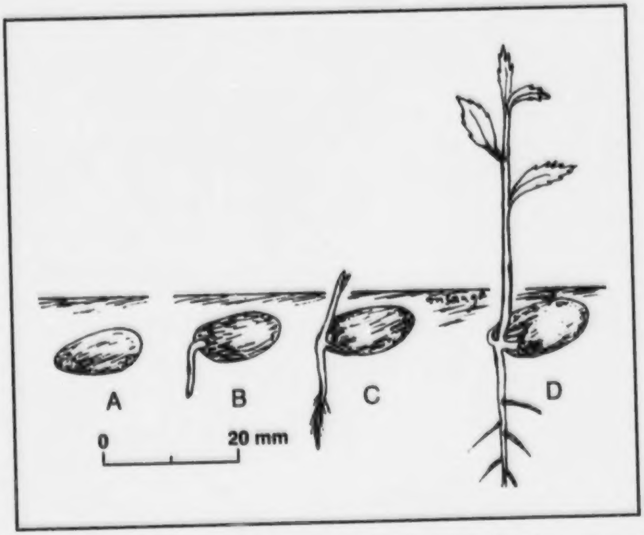


Figure 54. Stages in seed germination and early development of *Brackenridgea zanguebarica* seedlings. (A) At sowing, **(B)** at 6 weeks, **(C)** at 8 weeks, **(D)** 12 weeks after sowing.

Bridelia micrantha (Hochst.) Baill.

Syn. *Candelabria micrantha* Hochst.

EUPHORBIACEAE

Other names

Mwiza (Kiswahili, Kisambaa, Kividunda); mwira (Kipare); mushamako (Kihaya); mmarie (Kichaga); musumba, mkalakore (Kiluguru).

Fruit morphology and seed extraction

The fruits are small, oval, and light green, turning purple-black when ripe. Ripe fruits are picked from trees or collected from the ground soon after natural shedding. They are then squashed by hand to remove the skin and pulp around the seed. The seeds are cleaned by washing in water, and are dried in the shade for two days. About 10 kg of fruits produce 1 kg of seed.

Seed morphology

The seed is light green, almost egg shaped, with deep longitudinal grooves, about 6 mm long and 4 mm broad. There are about 19 500 seeds per kilogram.

Seed storage

The seed is recalcitrant and should be packed in small quantities (less than 5 kg) in cotton bags or gunny bags made of sisal or jute fibre. Alternatively they can be kept in wire mesh trays under shade. Both methods provide good ventilation.

The seeds cannot tolerate desiccation below 25% moisture content and should not be stored at freezing temperatures. Seeds should be sown within two weeks after collection.

Seed presowing treatment

The seed does not require any pretreatment.

Seed germination

Germination is epigeal (Figure 55). The radicle emerges and develops into a taproot. The hypocotyl elongates, bending greatly, and carries the seed coat on the cotyledons. Later the seed coat falls off. The leafy cotyledons expand, split and change colour from white to green.

Germination is very good and uniform, reaching as high as 90% after 25 days and 100% after 30 days from sowing day.

Plant uses

The leaf sap is used as a salve to treat sore eyes. A decoction of the roots is used as a remedy for severe epigastric pain. It is also used as a purgative, an anthelmintic and an antidote to poison. The timber is used for interior carpentry, and round poles are recommended for hut-building. Branches are cut during the dry season to feed to goats.

The tree yields good charcoal and excellent firewood. The charcoal obtained from the heartwood was used traditionally by the Wapare people of north-eastern Tanzania in iron smelting and smithing. A red dye is obtained from the bark and a black dye from the leaves and wood. The fruits are favoured by birds and are also consumed by people in times of emergency.

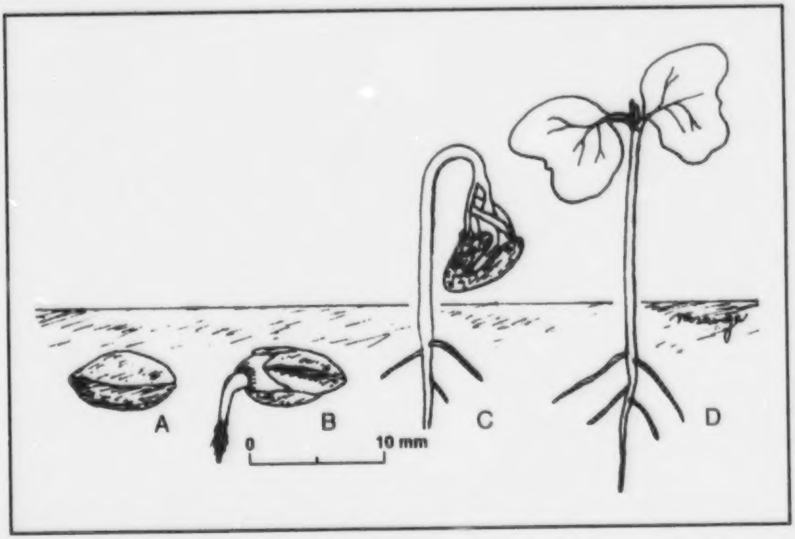


Figure 55. **Stages in seed germination and early development of *Bridelia micrantha* seedlings. (A)** At sowing, **(B)** at 14 days, **(C)** at 21 days, **(D)** at 28 days after sowing.

Brucea antidysenterica J.F. Mill.
SIMAROUBACEAE

Other names

Mrikawandu (Kichaga); ithibati (Kipare).

Fruit morphology and seed extraction

The fruit is a bright red drupe, thickest in the middle and narrowing towards both ends; it is about 1.2 cm long. Ripe fruits are collected from trees and squashed by hand to remove the skin and pulp. The seeds are separated by washing and floating the skin and pulp in water. The seeds are then dried in the sun. About 8 kg of fruits produce 1 kg of seeds.

Seed morphology

The seed is light yellow, egg-shaped, and about 9 mm long and 5 mm wide. The endocarp (stone) is thin and hard, and is prominently streaked by strands of ducts resembling a network of fibres. Beneath the endocarp lies a membraneous seed coat. There are about 10 000 seeds per kilogram.

Seed storage

Seeds are intermediate between recalcitrant and orthodox, and should be kept in a cool (2–5°C) dry place. Where such conditions are not available, seeds can be kept at ambient air temperature but out of direct sunshine. Seeds should be sown within six months after collection.

Seed presowing treatment

The endocarp should be completely removed, retaining only the inner membrane.

Seed germination

Germination is epigeal (Figure 56). The cotyledons expand and split the membrane. The radicle emerges and elongates to form a taproot. The extending hypocotyl carries the cotyledons above the germination medium.

Germination is very good and uniform, attaining 80% after 20 days and 100% after 27 days from sowing.

Plant uses

The leaf and root are used as remedies for stomach pains and upsets. The root, bark and fruit are used as remedies for diarrhoea, fever, dysentery and intestinal worms. A milk infusion is given to children to relieve asthma. A paste prepared from butter, powdered leaves and young twigs is used to treat bone decay, tuberculosis and cancerous tumours, as well as skin diseases, including leprosy.

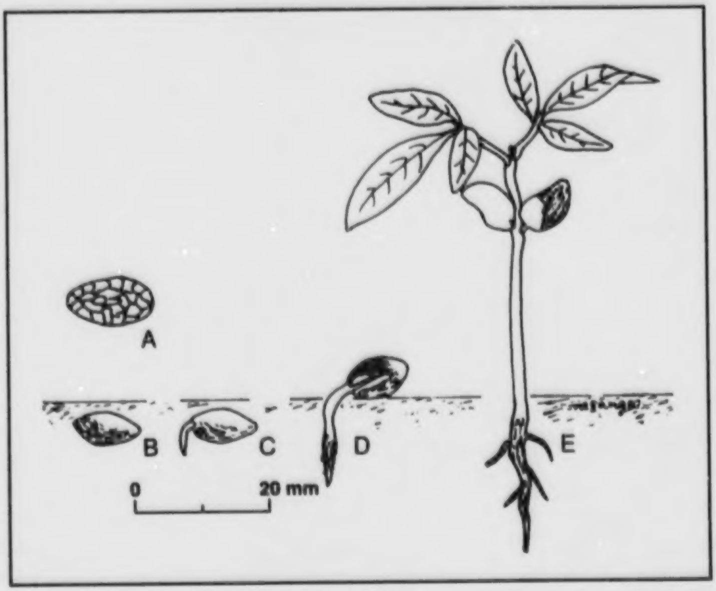


Figure 56. **Stages in seed germination and early development of *Brucea antidysenterica* seedlings. (A)** Seed with its endocarp before treatment, **(B)** seed with its seed coat removed at sowing, **(C)** at 15 days, **(D)** at 20 days, **(E)** at 50 days after sowing.

Burkea africana Hook.

LEGUMINOSAE: CAESALPINIOIDEAE

Other names

Mkarati, mgando (Kinyamwezi); msangala (Kihehe).

Fruit morphology and seed extraction

The fruit is a pod, thickest in the middle and narrowing towards both ends, 5 cm long and 2.5 cm wide, containing one to four seeds, brown when ripe, and almost woody. The ripening pods are collected from the tree and dried in the sun. After drying, the pods are opened by hand to extract seed. Alternatively the pods may be heaped on a tarpaulin or hessian sheeting material and beaten well with sticks to detach the seeds. The seeds are then cleaned by shaking and winnowing. About 10 kg of fruits produce 1 kg of seeds.

Seed morphology

The seed has two, more or less parallel, sides and rounded ends; it is about 10 mm long and 6 mm broad, light brown, and compressed, with a hard seed coat. There are about 14 000 seeds per kilogram.

Seed storage

The seed is orthodox and can be stored for three years at room temperature without significant loss of viability, if kept dry and free of insects.

Seed presowing treatment

Small quantities may be pretreated using a hot wire. Bulk quantities are pretreated by the hot water method (*see* section on seed presowing treatments).

Seed germination

Germination is epigeal (Figure 57). The seed coat softens as the seed absorbs water. The cotyledons swell greatly and rupture the seed coat at the scar. The radicle emerges and develops into a taproot. The hypocotyl elongates, bending slightly, and rises, carrying the seed coat and cotyledons above the germination medium. The seed coat later falls off with the expansion of the cotyledons.

Germination is usually fair but moderately uniform. It reaches 10% after 10 days and 50% after 25 days from sowing.

Plant uses

The tree produces an excellent, very durable timber which is used for joinery, mining timbers, sleepers, bridges, decking and heavy construction. The powdered bark and fruit are used by fishers to stupefy fish, and are also used for tanning. The fruit is used as a remedy for dysentery.

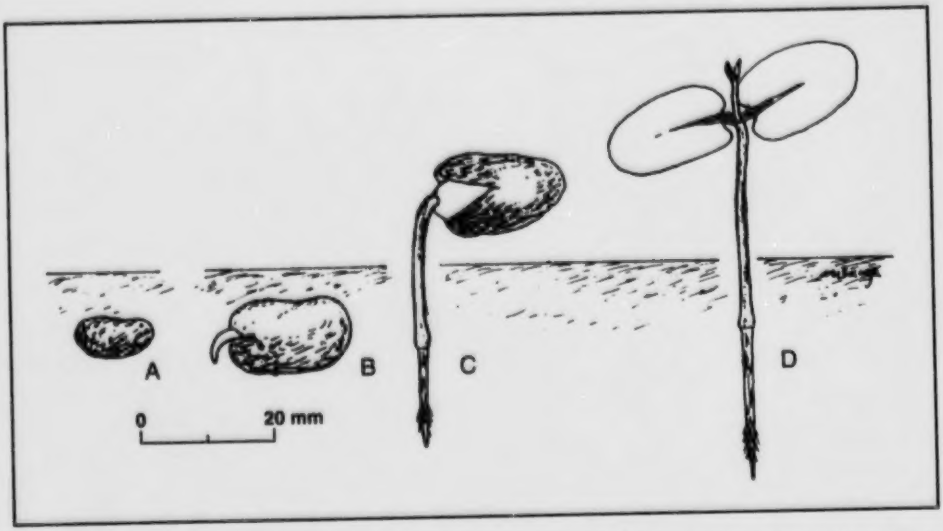


Figure 57. **Stages in the germination of *Burkea africana* seed. (A)** At sowing, **(B)** at 5 days, **(C)** at 8 days, **(D)** at 20 days after sowing.

Bussea massaiensis (Taub.) Harms

LEGUMINOSAE: CAESALPINIOIDEAE

Other names

Mbegu (Kigogo); mbetu (Kinyamwezi); mfetru (Kinyaturu).

Fruit morphology and seed extraction

The fruit is a pod, elongated and thickened at the end, grooved down the middle of each side, about 10 cm long and 2 cm wide, containing up to three seeds. Pods are covered with rusty, short, soft hairs and are suspended above the leaves on the top of the tree. When dry, pods open explosively to release seeds. About 5 kg of fruits produce 1 kg of seeds.

Seed morphology

The seed is brown, shiny, hard, and slightly flattened; it is about 1.8 cm long and 1.0 cm wide. There are about 2000 seeds per kilogram.

Seed storage

The seed is orthodox and can be stored up to two years at room temperature without significant loss of viability, if kept dry and free of insects.

Seed presowing treatment

The seed does not require any pretreatment.

Seed germination

Germination is epigeal (Figure 58). After imbibing water, the seed coat softens and ruptures to release the developing radicle. The root descends while the hypocotyl elongates, raising the cotyledons and seed coat above the germination medium. The seed coat falls off, and cotyledons open and change colour from white to green.

Germination is very good and uniform, attaining 100% after 10 days.

Plant uses

The seeds are roasted and eaten by people. The pods and leaves provide valuable livestock and game feed.

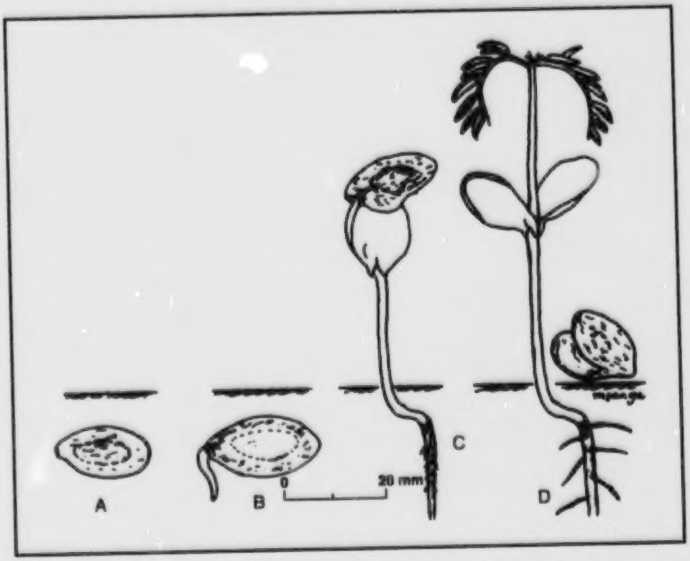

mpanga
C
0
20 mm
A
B
D

Figure 58. Stages in seed germination and early development of *Bussea massaiensis* seedlings. (A) At sowing, (B) at 4 days, (C) at 8 days, (D) at 14 days after sowing.

Caesalpinia trothae Harms

LEGUMINOSAE: CAESALPINIOIDEAE

Other names

Mburuga (Kiswahili).

Fruit morphology and seed extraction

The fruit is a woody pod, rounded to slightly elongated; it is about 3.5 cm long with a narrow, bent tip. Each pod contains up to three seeds. Dry pods are threshed in a gunny bag using a stick, and seeds are cleaned by shaking and winnowing. About 5 kg of pods produce 1 kg of seeds.

Seed morphology

The seed is light brown, almost round, with a bump at the scar and four low ridges running from the base to the opposite side; it is about 1 cm across. There are about 2000 seeds per kilogram.

Seed storage

The seed is orthodox and can be stored for up to two years at room temperature if kept dry and free of insects.

Seed presowing treatment

The seed does not require any pretreatment.

Seed germination

Germination is epigeal (Figure 59). The seed absorbs water and swells greatly. The radicle protrudes at the scar end and descends. The seed coat is carried up on the cotyledons by the expanding hypocotyl. The first leaves then push their way up between the cotyledons and the seed coat falls off.

Germination is very good with fresh seed, reaching 40% after 10 days and 95% after 15 days from sowing.

Plant uses

The plant is ornamental and produces beautiful, pale pink flowers. It is also good for soil improvement, particularly in areas which are occasionally water-logged. The leaves are a valuable source of game feed.

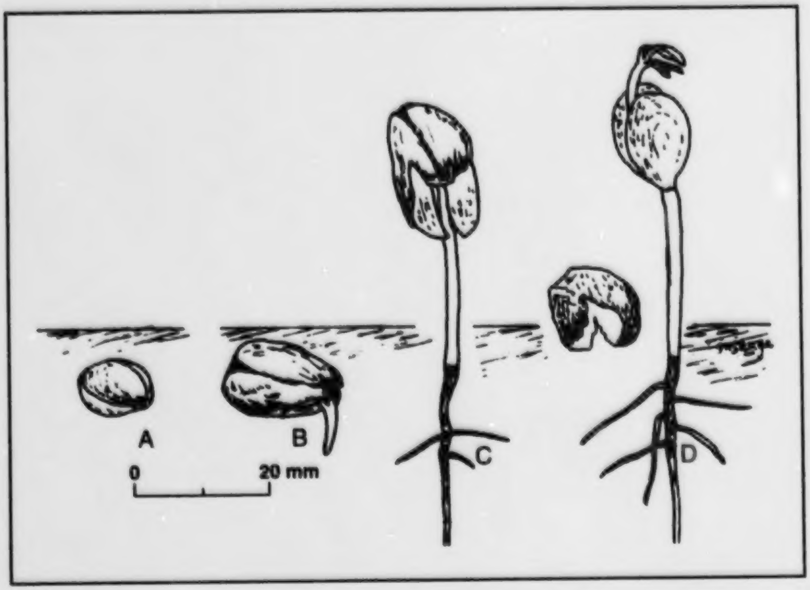


Figure 59. Stages in seed germination and early development of *Caesalpinia trothae* seedlings. (A) At sowing, **(B)** at 3 days, **(C)** at 7 days, **(D)** at 9 days after sowing.

Calpurnia aurea Baker subsp. *aurea*
LEGUMINOSAE: PAPILIONOIDEAE

Other names

East African laburnum; mlangau (Kichaga); laiyangaloni (Kimasai); quarerei (Iraqw).

Fruit morphology and seed extraction

The fruit is a straight pod, somewhat membraneous, 13 cm long, and several-seeded. The unopened pods remain attached to the tree for a long time. Dry pods are threshed in a gunny bag, using a stick. Seeds are cleaned by shaking and winnowing. For extraction of bulk quantities, a flailing thresher and an air-screen cleaner can be used (as for *Acacia nilotica*). About 12 kg of pods produce 1 kg of seed.

Seed morphology

The seed is yellowish-brown, kidney-shaped with round tips, and has a hard seed coat. It is small, 4 mm long and 3 mm broad. There are about 25 000 seeds per kilogram.

Seed storage

The seed is orthodox and can be stored for three years at room temperature without significant loss of viability, if kept dry and free of insects.

Seed presowing treatment

The hot water treatment should be used (*see* section on seed presowing treatments).

Seed germination

Germination is epigeal (Figure 60). The radicle emerges first, then the hypocotyl elongates, slightly bending, and carries the cotyledons above the germination medium. The seed coat usually remains partially enclosing the cotyledons until they split and the seed coat falls off. The cotyledons change from white to green but later become brown and shrivelled.

Germination is good and moderately uniform, reaching 30% after 15 days and 72% after 20 days.

Plant uses

The tree is used to provide shade in banana and coffee farms in the highland areas of Tanzania. The branches are cut and the leaves fed to goats. The wood makes excellent firewood.

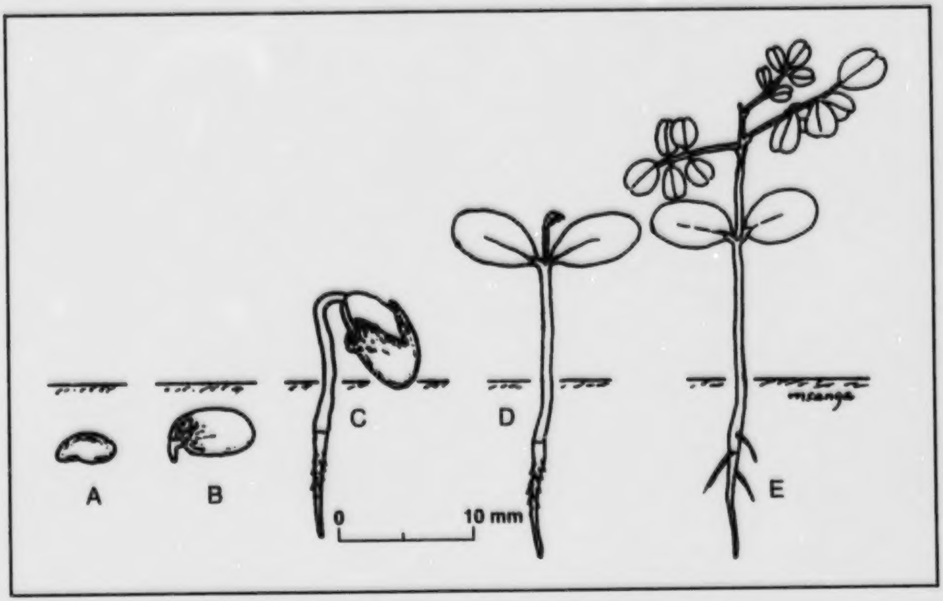

C
D
msanga
A
B
E
0
10 mm

Figure 60. Stages in seed germination and early development of *Calpurnia aurea* seedlings. (A) At sowing, (B) at 4 days, (C) at 15 days, (D) at 30 days after sowing.

Catunaregam spinosa (Thunb.) Tirveng. subsp. *taylorii* (S. Moore) Verdc.

Syn. *Randia taylorii* S. Moore

RUBIACEAE

Other names

Mpongolo, mchangoko (Kinyamwezi); kiumang'ombe (Kirangi); sipongolo (Kibende).

Fruit morphology and seed extraction

The fruit is a fleshy egg-shaped drupe, about 3 cm long and 2 cm broad, green at first and turning yellow when ripe. The tip is crowned with the remains of the persistent calyx. Each fruit contains one to five seeds. The seeds are squashed out from the skin and the pulp washed in water. This must be done while the fruits are still fresh, because when dry they become very hard. Empty seeds float on the surface of water and are discarded. Those which sink to the bottom are considered viable and retained. They are dried in the sun for four days.

Seed morphology

The seeds are egg-shaped, small, about 4 mm long and 3 mm broad, smooth coated, and black. There are about 40 000 seeds per kilogram.

Seed storage

The seed is intermediate between orthodox and recalcitrant. It can be stored for three months in a cool place (16°C).

Seed presowing treatment

The seed does not require any pretreatment.

Seed germination

Germination is epigeal (Figure 61). The radicle emerges from one end of the seed and pushes its way downwards. The hypocotyl elongates and rises above the germination medium. The cotyledons enlarge and split the seed coat, which later falls off .

Germination is very good and uniform, reaching 80% after 15 days and 100% after 20 days from sowing.

Plant uses

The leaves provide fodder to livestock. The roots are used in the preparation of traditional medicines, while the fruits are used in an emetic. The wood makes good firewood and is also used for hut building.

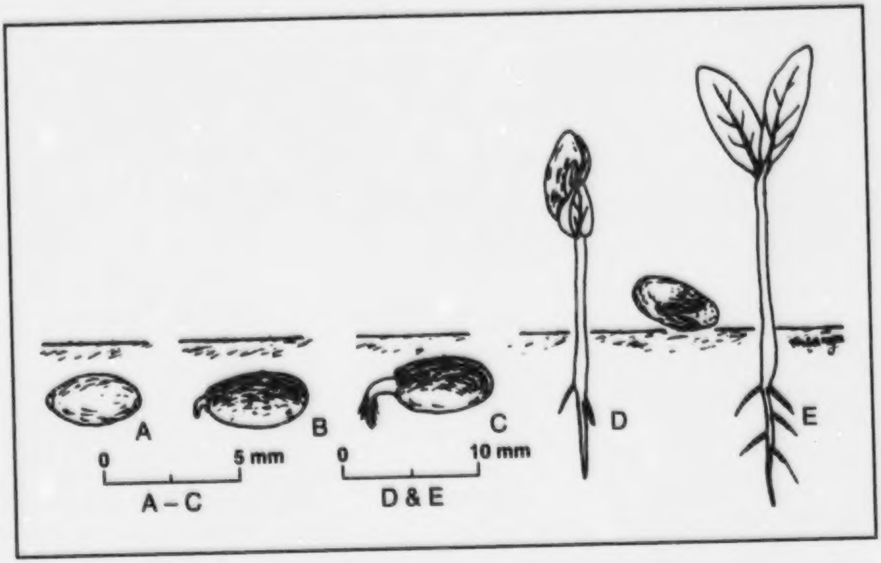

A
B
C
D
E
0
5 mm
A – C
0
10 mm
D & E

Figure 61. **Stages in seed germination and early development of *Catunaregam spinosa* seedlings. (A)** At sowing, **(B)** at 5 days, **(C)** at 10 days, **(D)** at 25 days, **(E)** at 30 days after sowing.

Cephalosphaera usambarensis (Warb.) Warb.

MYRISTICACEAE

Other names

Mtambara (Kiswahili).

Fruit morphology and seed extraction

The fruit is large, about 6 cm long and 4 cm broad, with a yellow-green fleshy pericarp. After ripening it splits longitudinally into two lobes, releasing a single seed. Clean seeds are collected from the ground soon after natural shedding.

Seed morphology

The seed is egg-shaped and large, about 5 cm long and 3 cm broad. It is covered by a thin cream-coloured aril loosely attached at the base of the seed. The aril is usually detached during seed fall. The seed has a thin coat and a small embryo embedded in a massive endosperm. This is one of the biggest seeds of indigenous trees in Tanzania. There are about 35 seeds per kilogram.

Seed storage

The seed is recalcitrant and should be packed in small quantities (less than 10 kg) in cotton bags or in gunny bags made of sisal or jute fibre. Alternatively they can be kept in wire mesh trays under shade. Both methods provide good ventilation.

The seeds cannot tolerate desiccation below 25% moisture content, and should not be stored at freezing temperatures. Seeds should be sown within six weeks after collection.

Seed presowing treatment

Pretreatment is not necessary, but the germination period is shortened by warm stratification in moistened forest litter under shade for three weeks.

Seed germination

Germination is hypogeal (Figure 62). It commences with the emergence of the thick whitish radicle. The cotyledonary stalks elongate greatly and the base of the young stem is enveloped by a tube formed by the united bases of the stalks.

Germination is very good and uniform. It reaches 90% after six weeks and 97% after seven weeks from sowing.

Plant uses

This tree provides the best all-purpose timber in Tanzania. The wood is used for building, furniture and plywood production. *Cephalosphaera usambarensis* is endemic in the Usambara and Nguru mountains in Tanzania. It is an important climax species and is suitable for water catchment planting in those areas.

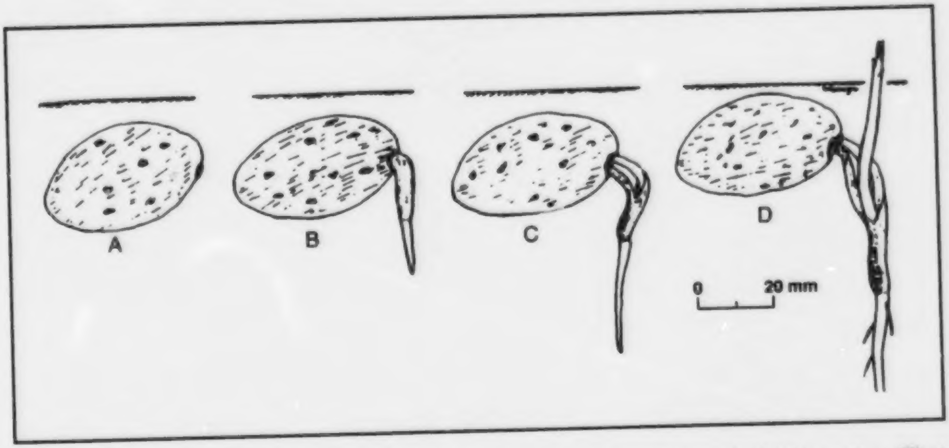


Figure 62. **Stages in the germination of *Cephalosphaera usambarensis* seed. (A)** At sowing, **(B)** at 25 days, **(C)** at 30 days, **(D)** at 40 days after sowing.

Clerodendrum cephalanthum Oliv.

VERBENACEAE

Other names

Msolo (Kisambaa); mswaguyu (Kizaramo); kilazingi (Kizigua).

Fruit morphology and seed extraction

The fruit is a blackish spherical drupe, up to 1.5 cm in diameter. It has a fleshy layer and four seeds. Ripe fruits are collected from the ground and squashed by hand to remove the fleshy layer. The seeds are separated by washing and floating the pulp in water; seeds are then dried in the sun. About 8 kg of fruits produce 1 kg of seeds.

Seed morphology

The seed is a brown spherical nutlet with a hard stony endocarp, up to 1 cm long. There are about 10 000 seeds per kilogram.

Seed storage

The seed is orthodox and can be stored for four years at room temperature without significant loss of viability if kept dry and free of insects.

Seed presowing treatment

Complete removal of the endocarp by light hammering is recommended.

Seed germination

Germination is intermediate between epigeal and hypogeal (Figure 63). The seed absorbs water and swells. The radicle emerges through the scar side and develops into a taproot. The cotyledons unfold to release the developing epicotyl. The hypocotyl cannot be distinguished, and the cotyledons remain partly buried in the germination medium.

Germination is good and fairly uniform, attaining 5% after 15 days and 60% after 25 days from sowing.

Plant uses

The hollow stem is traditionally used in making smoking pipes. The root is used as a purgative.

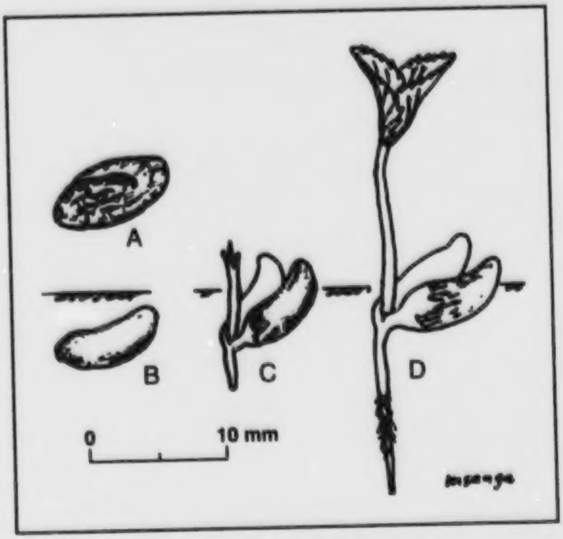


Figure 63. **Stages in the germination of *Clerodendrum cephalanthum* seed.** **(A)** Seed with the stone endocarp intact, **(B)** the kernel at sowing day, **(C)** at 15 days, **(D)** at 30 days after sowing.

Clutia abyssinica Jaub. & Spach
EUPHORBIACEAE

Other names

Mvuruku (Kipare); mhende (Kisambaa); mwitanmwaru (Kikerewe).

Fruit morphology and seed extraction

The fruit is a rounded woody capsule, which breaks naturally into three parts. Ripening fruits are collected from the plant and drying is completed in the sun. After drying, the fruits are broken by hand or put in cloth bags and lightly crushed by hand to release the seeds.

Seed morphology

The seed is slightly elongated with a caruncle at the scar. It is small, about 2 mm long, with a black, shiny, brittle seedcoat. There are about 120 000 seeds per kilogram.

Seed storage

Seeds are intermediate between orthodox and recalcitrant, and should be stored in a cool (2–5°C) dry place. Where such conditions are not available, seeds can be kept at ambient air temperature, out of direct sunshine. Seeds should be sown within four months after collection.

Seed presowing treatment

The seed does not require any pretreatment.

Seed germination

Germination is epigeal (Figure 64). The seed coat cracks, starting at the scar point. The radicle protrudes and develops into a taproot. The hypocotyl elongates, bending slightly, and soon straightens, carrying the seed coat and cotyledons above the germination medium. Later the seed coat falls off as the cotyledons separate and expand. Cotyledons change colour from white to green.

Germination is poor but fairly uniform. It reaches 5% after 15 days and 10% after 35 days from sowing.

Plant uses

A root decoction is used as medicine to expel intestinal worms, and as a remedy for habitual miscarriage, enlarged spleen and influenza. The wood is smoked by women to control menstrual periods. The root decoction is also drunk to cure colds and malaria, but smoking leaves is considered more effective. It is also taken as an aphrodisiac and purgative, and the decoction mixed with *Rhamnus staddo* is taken as a remedy for sterility in women. A decoction of root in chicken soup is taken as a remedy for measles and coughs in children. A concentrated cold extract from senescing leaves, or a root decoction, is applied to the body by mopping to cure skin diseases, especially ringworm. A cold extract from bark or leaves mixed with a kind of local brew known as "dengelua" (Kipare) is taken as an anthelminthic. A mixed root decoction made together with *Solanum incanum* and *Osyris lanceolata* is administered as a remedy for cancer.

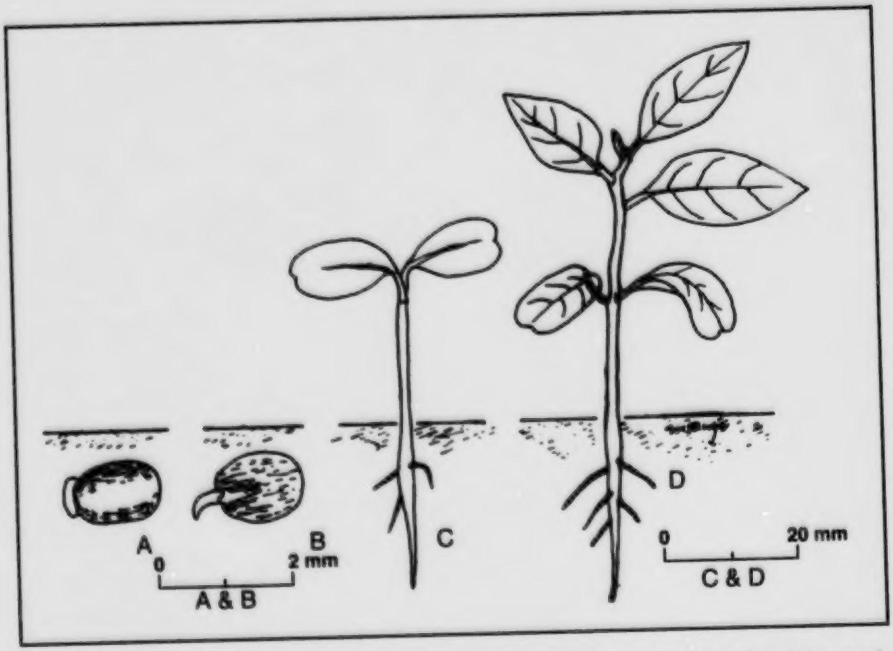

A
B
C
D
0
2 mm
A & B
0
20 mm
C & D

Figure 64. Stages in seed germination and early development of *Clutia abyssinica* seedlings. (A) At sowing, (B) at 15 days, (C) at 30 days, (D) at 60 days after sowing.

Combretum zeyheri Sond.
COMBRETACEAE

Other names

Large-fruited combretum; mlama (Kiswahili); muama mjewa (Kipare).

Fruit morphology and seed extraction

Fruits are straw-coloured, about 5 cm long and 7 cm wide, with four wings; each wing is 2 cm wide (Figure 65). This is the largest of the combretum fruits. About 2 kg of fruits produce 1 kg of seeds.

Seed morphology

The seed is about 2.5 cm long and 1 cm wide, elongated with rounded tips, and has a thin brown seed coat. It has four longitudinal grooves, which mark the position of the wings. There are about 1000 seeds per kilogram.

Seed storage

Seeds are intermediate between orthodox and recalcitrant, and can be stored for two months at room temperature without significant loss of viability.

Seed presowing treatment

The wings and endocarp should be completely removed, retaining only the seed enclosed in the membraneous seed coat (Figure 66).

Seed germination

Germination is epigeal (Figure 66). The seed absorbs water and enlarges slightly, and the cotyledons split the membrane. The radicle emerges from the wide end of the seed and elongates to form a taproot. The hypocotyl is very short and carries two leafy cotyledons. The cotyledons are folded together like a cup and, on exposure to light, change colour from white to yellowish-green.

Germination is fair and uniform if the endocarp is removed. It reaches 20% after 15 days and 45% after 25 days. Without removal of the endocarp the germination remains below 20% and is only completed after three months. Research in germination improvement could be useful.

Plant uses

The fibrous roots are used in making baskets and fish traps. The wood is hard and termite-resistant, and is used for hut building, charcoal and firewood.

Figure 65. *Combretum zeyheri* fruit.

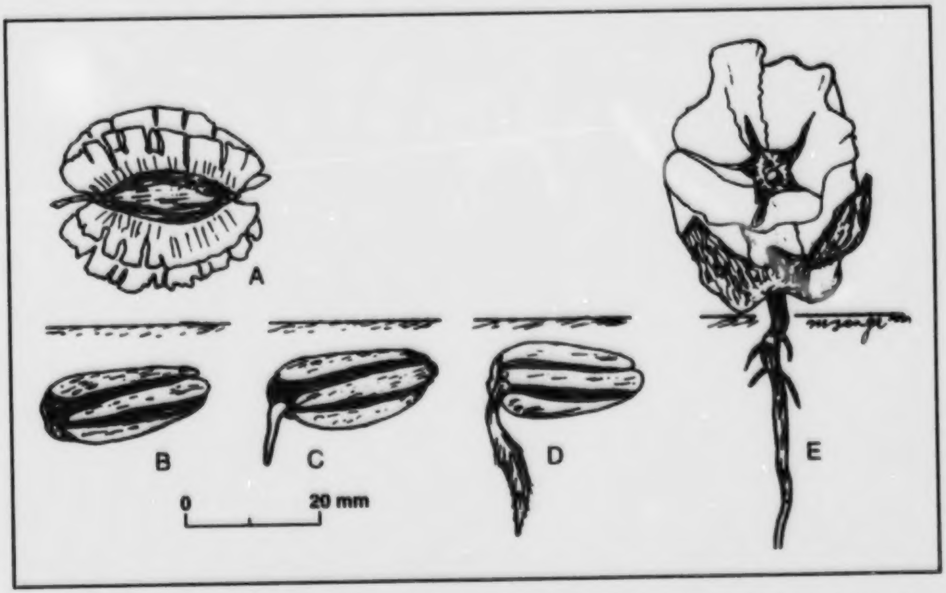


Figure 66. Stages in the germination of *Combretum zeyheri* seed. (A) Fruit before seed extraction, (B) seed at sowing, (C) at 4 days, (D) at 5 days, (E) at 15 days after sowing.

Cordia africana Lam.

Syn. *Cordia abyssinica* R. Br.

BORAGINACEAE

Other names

Large-leaved cordia; mrungurya (Kipare); mringaringa (Kichaga, Kimeru, Kimasai); mfufu (Kisambaa); msinzizi, mbapu (Kiluguru).

Fruit morphology and seed extraction

The fruit is a round, fleshy drupe, about 1 cm in diameter, yellow when mature, and has mucilaginous flesh. Short fragments of the calyx persist at the fruit base. Ripe fruits are mixed with sand and pounded in a mortar to extract seeds; alternatively, a flailing thresher can be used with large quantities of water. About 10 kg of fruits produce 1 kg of seeds.

Seed morphology

The nut is very hard, with round tips, and about 8 mm in diameter; it has a mucilaginous covering. Each nut contains one to four seeds, each with a thin membraneous seed coat. For practical purposes each fruit with the pulp removed is considered a seed. There are about 5000 nuts per kilogram.

Seed storage

Properly dried nuts can be stored for two years at room temperature without significant loss of viability.

Seed presowing treatment

The nuts should be soaked in cold water for three days. The water should be changed after 12 hours.

Seed germination

The cotyledons expand (Figure 67), causing the nut to burst at the scar end. The radicle develops, and the hypocotyl elongates and carries the cotyledons above the germination medium. The nut remains in the germination medium. A nut may produce more than one seedling.

Germination is good but sporadic, reaching 30% after two weeks and 70% after five weeks from sowing.

Plant uses

The tree provides firewood, timber, fodder, bee forage, and shade in banana and coffee farms. The wood is used for making traditional beehives, mortars and utensils. Roots are used for treating chest pains and sore throats. This is one of the sacred trees of the Waarusha tribe of north-eastern Tanzania.

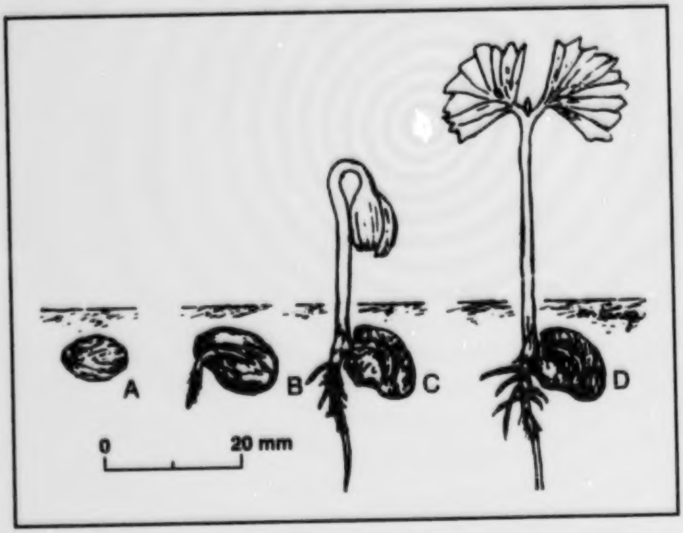


Figure 67. **Stages in seed germination and early development of *Cordia africana* seedlings. (A)** At sowing, **(B)** at 7 days, **(C)** at 12 days, **(D)** at 15 days after sowing.

Cordyla africana Lour.

LEGUMINOSAE: PAPILIONOIDEAE

Other names

Wild mango; mkwata (Kigogo, Kihehe, Kikaguru); mgwata, mroma (Kiswahili); mbachanga (Kichaga).

Fruit morphology and seed extraction

The fruit is a large pod, almost round, about 4 cm long and 3 cm broad, beaked at the tip, yellow when ripe, with fine green streaks. It contains soft pulp and one or two seeds. The pulp and skin are removed using a knife and the seeds washed in water. About 5 kg of fruits produce 1 kg of seeds.

Seed morphology

The seed is large and fleshy, 3 cm long and 2 cm broad, with rounded ends. The seed coat is thin, light green and streaked by strands of ducts resembling a network of fibres. There are about 100 seeds per kilogram.

Seed storage

The seed is recalcitrant and should be packed in small quantities (less than 10 kg) in cotton bags or gunny bags made of sisal or jute fibre. Alternatively, they can be kept in wire mesh trays under shade. Both methods provide good ventilation.

The seeds cannot tolerate desiccation below 25% moisture content and should be stored at room temperature. Seeds should be sown within four weeks after collection.

Seed presowing treatment

The seed does not require pretreatment.

Seed germination

Germination is hypogeal (Figure 68). The seed coat splits at the scar point and the radicle protrudes. The epicotyl splits the two cotyledons apart and elongates, leaving the cotyledons within the seed coat, within the germination medium.

Germination is very good and uniform, but a bit delayed. It reaches 60% after four weeks and 90% after five weeks from sowing.

Plant uses

The fruit pulp is edible, and the stems are used for building poles and live fences. The tree is widely used to provide shade around the homestead.

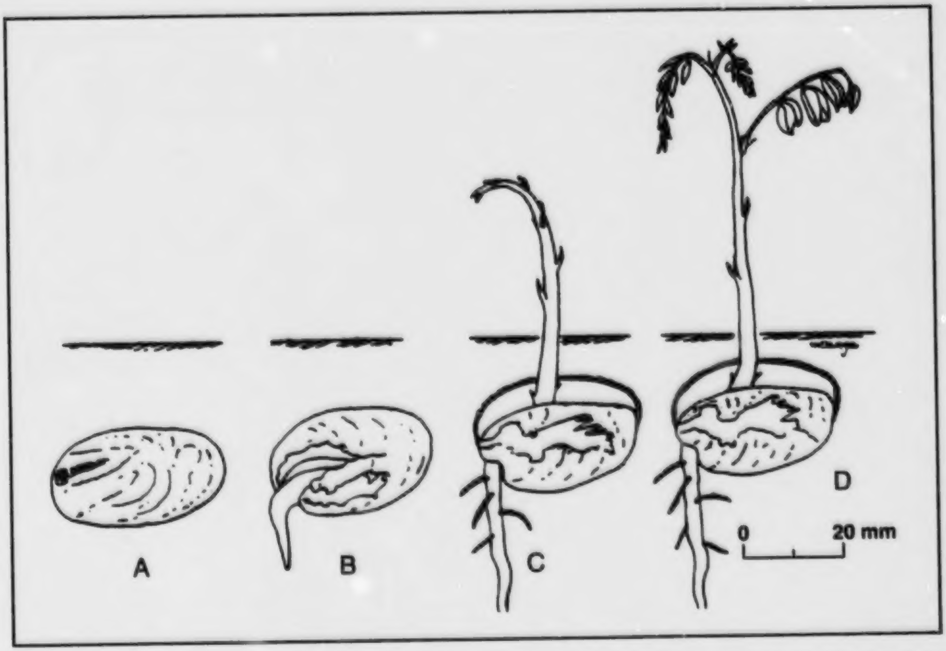


Figure 68. **Stages in seed germination and early development of *Cordyla africana* seedlings. (A)** At sowing, **(B)** at 3 weeks, **(C)** at 4 weeks, **(D)** at 6 weeks after sowing.

Cordyla densiflora Milne-Redh.

LEGUMINOSAE: PAPILIONOIDEAE

Other names

Mkwata (Kigogo, Kihehe, Kikaguru).

Fruit morphology and seed extraction

The fruit is a large fleshy pod, almost egg-shaped, about 5 cm long and 3 cm wide, beaked at the tip, and yellowish-green when ripe, with fine reddish-green streaks. It contains soft pulp and one seed. The pulp and skin are removed using a knife and the seeds washed in water. About 5 kg of fruits produce 1 kg of seeds.

Seed morphology

The seed is large and fleshy, about 3.5 cm long and 3 cm wide (Figure 69). The seed coat is light green, thin and streaked by strands of ducts resembling a network of fibres. There are about 90 seeds per kilogram.

Seed storage

The seed is recalcitrant, and should be stored in small quantities (less than 10 kg) in cotton bags or in gunny bags made of sisal or jute fibres, or kept in wire mesh trays under shade. Both methods provide good ventilation.

The seeds can not tolerate desiccation below 25% moisture content, and should be stored at room temperature. Seeds should be sown within four weeks after collection.

Seed presowing treatment

The seed does not require pretreatment.

Seed germination

Germination is hypogeal (Figure 70). The seed coat splits at the scar point and the radicle protrudes. The epicotyl splits the two cotyledons apart and elongates, while the cotyledons remain within the seed coat, buried in the germination medium.

Germination is very good and uniform if seed is fresh. It reaches 50% after three weeks and 80% after four weeks from sowing.

Plant uses

The fruit pulp is edible. The stems are used for building poles, traditional stools, grain mortars and live fences.

Figure 69. *Cordyla densiflora* seeds.

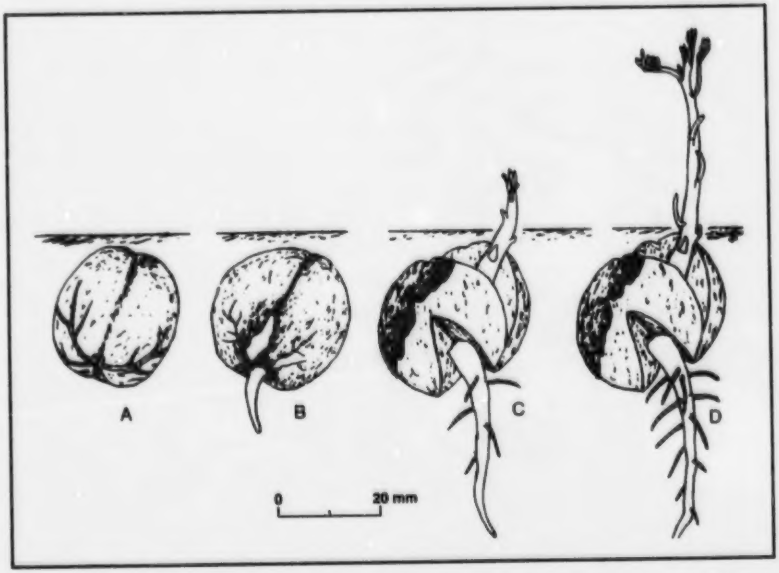


Figure 70. Stages in seed germination and early development of *Cordyla densiflora* seedlings. (A) At sowing, (B) at 7 days, (C) at 14 days, (D) at 20 days after sowing.

Crotalaria grandibracteata Taub.

LEGUMINOSAE: PAPILIONOIDEAE

Other names

Ichekechi (Kichaga); mtanjigha (Kipare); mzongozongo (Kisambaa); songa (Kinyaturu).

Fruit morphology and seed extraction

The fruit is a club-shaped, inflated pod with many rattling seeds. It is about 8 cm long and 2 cm broad, pale green at first, and turning black at maturity. Pods should be dried in the sun, then threshed in a gunny bag using a stick. Seeds are cleaned by shaking and winnowing. About 8 kg of fruits produce 1 kg of seeds.

Seed morphology

The seed is small, heart-shaped, up to 7 mm long, smooth and brown. There are about 40 000 seeds per kilogram.

Seed storage

The seed is orthodox and can be stored for two years at room temperature, if kept dry.

Seed presowing treatment

Seeds should be soaked in cold water for six hours.

Seed germination

Germination is epigeal (Figure 71). The seed absorbs water and swells, and the radicle protrudes and descends. The seed coat is carried up by the expanding hypocotyl on the cotyledons; these then separate, and the seed coat falls off.

Germination is very good and uniform. It reaches 30% after seven days and 90% after 14 days from sowing.

Plant uses

The plant is fast growing, and has potential as a green manure crop on fallow fields. It provides a very strong, useful fibre, fodder, and bee forage, and can be planted near houses as an ornamental.

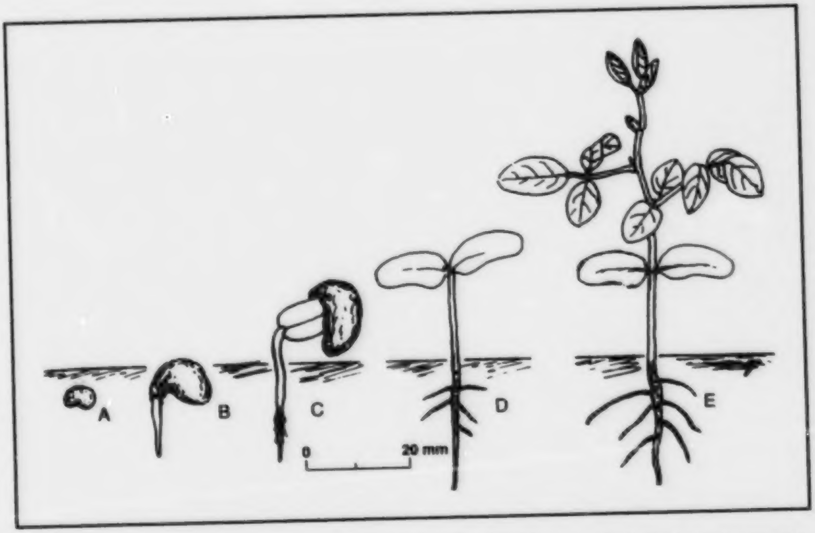


Figure 71. Stages in seed germination and early development of *Crotalaria grandibracteata* seedlings. (A) At sowing, (B) at 3 days, (C) at 5 days, (D) at 7 days, (E) at 6 weeks after sowing.

Croton macrostachys Hochst. ex Delile

EUPHORBIACEAE

Other names

Broad-leaved croton; mfurifuri (Kipare); ifurufuru, mfurufuru (Kichaga); olobiago (Kiarusha); mshunduzi (Kisambaa); livuluku (Kinyakyusa).

Fruit morphology and seed extraction

The fruit is a small capsule, up to 7 mm in diameter; when mature, it splits open to release three seeds from each segment. To extract the seeds, fruits are dried in the sun for several days and threshed by hand. Seeds are cleaned by winnowing. About 6 kg of fruits produce 1 kg of seeds.

Seed morphology

The seed is shiny and grey, about 5 mm long and 3 mm broad, with a soft, cream-coloured aril. There are about 25 000 seeds per kilogram.

Seed storage

Seed is intermediate between recalcitrant and orthodox, and can be stored for up to six months at room temperature.

Seed presowing treatment

The seed does not need pretreatment before sowing.

Seed germination

Germination is epigeal (Figure 72). The seed coat cracks, starting at the aril point. The radicle protrudes and develops into a taproot. The hypocotyl elongates, bending slightly, and soon straightens, carrying the seed coat and cotyledons above the germination medium. As the two leafy cotyledons expand, the seed coat falls off.

Germination is fair but sporadic. It attains 6% after two weeks and 40% after four weeks, and continues.

Plant uses

The stem and branches are used for firewood, poles, and tool handles. The tree also provides bee forage and mulch, and is used for soil conservation. Liquid obtained from boiled roots is used to treat venereal diseases, while liquid from boiled bark, when mixed with liquid from *Hagenia abyssinica* flowers, is an effective purgative. A concentrated water extract of crushed leaves is applied as an ointment to treat skin diseases, particularly warts.

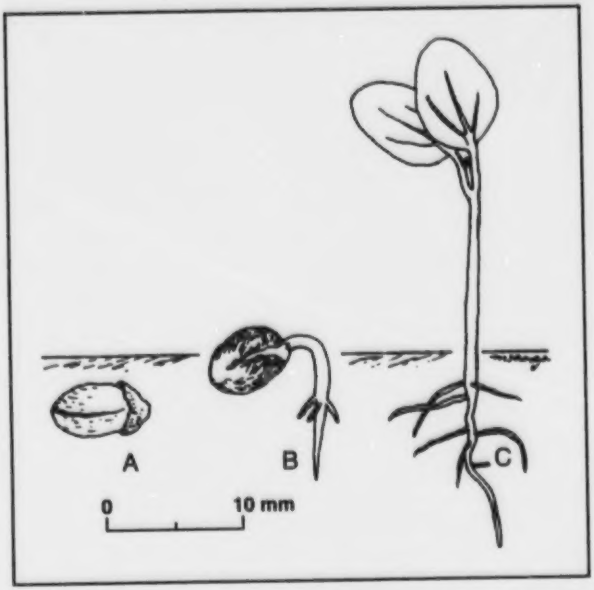


Figure 72. Stages in seed germination and early development of *Croton macrostachys* seedlings. (A) At sowing, (B) at 10 days, (C) at 14 days after sowing.

Croton megalocarpus Hutch.
EUPHORBIACEAE

Other names

Fever-berry croton; muhande (Kipare); menefu (Kiswahili); mlalai, mlande (Kichaga); muhihi (Kihaya); ol mergoit (Kimasai).

Fruit morphology and seed extraction

The fruit is a woody capsule, almost round, about 3 cm across, with three segments, becoming grey when ripe. Seeds may be extracted by cracking the fruit shell with a knife handle. Each fruit contains up to three seeds; some may abort. About 4 kg of fruits produce 1 kg of seeds.

Seed morphology

The seed is slightly elongated and flattened, about 1.5 cm long and 1.0 cm broad. It is grey with a brittle seed coat. There are about 1000 seeds per kilogram.

Seed storage

Seed is intermediate between orthodox and recalcitrant. Properly dried seed can be stored at room temperature for six months without significant loss in viability.

Seed presowing treatment

The seed does not require pretreatment before sowing.

Seed germination

Germination is epigeal (Figure 73). The seed coat cracks, then the radicle protrudes from the scar end and develops into a vigorous taproot. The hypocotyl elongates, bending greatly. Later the shoot straightens, and the seed coat may be carried above the germination medium by the two leafy cotyledons or left buried in the medium.

Germination is good and uniform. It attains 30% after 15 days and 75% after 30 days.

Plant uses

The tree provides poles, timber, shade near houses, mulch, and firewood; it is also planted as an ornamental due to its beautiful, rather flat crown. The flowers attract bees. Liquid from boiled bark is used to treat severe colds and pneumonia.

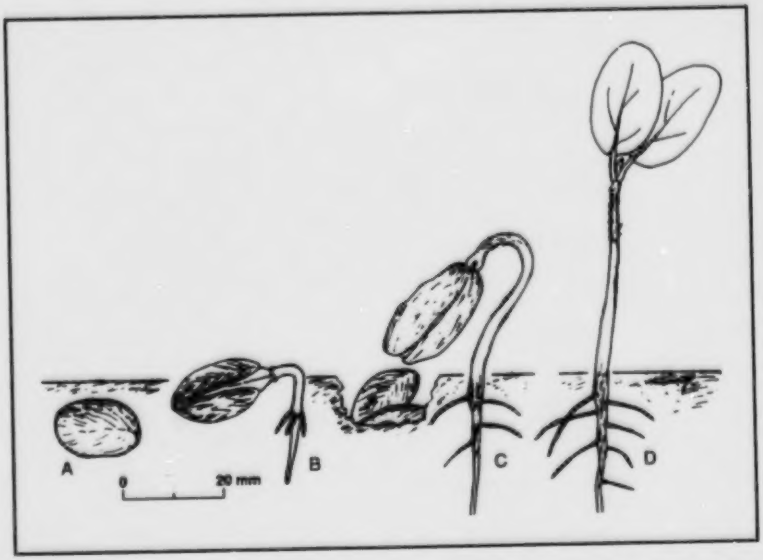


Figure 73. Stages in seed germination and early development of *Croton megalocarpus* seedlings. (A) At sowing, (B) at 7 days, (C) at 14 days, (D) at 18 days after sowing.

Dalbergia melanoxylon Guill. & Perr.
LEGUMINOSAE: PAPILIONOIDEAE

Other names

African blackwood; mpingo (Kiswahili); mwingo (Kipare); mugembe (Kinyamwezi).

Fruit morphology and seed extraction

The fruit is a small indehiscent pod, about 4.0 cm long and 1.5 cm broad, flat, usually straight, tapering to either end, and constricted between the seed chambers. Each pod contains up to four seeds.

The pods are collected from the tree. The first pods that fall when the tree is lightly shaken contain underdeveloped, insect damaged, or empty seeds, and should be rejected. Ripe pods are dark brown, and should be dried in the sun after collection. Seed extraction is very tedious, so pods are usually broken and pieces containing one or two seeds are sown. For small and valuable seed lots, the seeds can be removed from the pods by hand.

Seed morphology

The seed is small, about 1.0 cm long and 0.5 cm broad; it is flat, kidney-shaped, and dark brown, with a thin seed coat. There are about 40 000 clean seeds per kilogram, or 16 000 pieces of cut pods.

Seed storage

The seed is orthodox, and properly dried pods can be stored up to a year at room temperature without significant loss of viability.

Seed presowing treatment

Pods should be broken by hand into short pieces each containing one seed, soaked in cold water for six hours, and sown directly as short pieces. Seed extraction is not recommended because of the fragility of the seed; also, many pods are empty.

Seed germination

Germination is epigeal (Figure 74). The seed coat softens as the seed absorbs water. The radicle emerges at one end of the seed and descends to form a taproot. The hypocotyl bends on emerging from the seed, but soon straightens. The seed coat is carried up on the cotyledons, falling off later when the cotyledons expand and separate.

Germination is good but sporadic, reaching approximately 6% after 20 days and 60% after 40 days from sowing.

Plant uses

Dalbergia melanoxylon is one of the most valuable timbers of east Africa. It makes the finest clarinets, oboes, bagpipe chanters, guitar fret boards, walking sticks and bearings. Traditional uses include firewood, charcoal, pestles, combs, knife hafts and cups. The ancient, all-wood hoe of the western regions of Tanzania was made of *Dalbergia melanoxylon*, whence the Nyamwezi name for the timber, "mugembe". It is also used for carvings and other tourist curios.

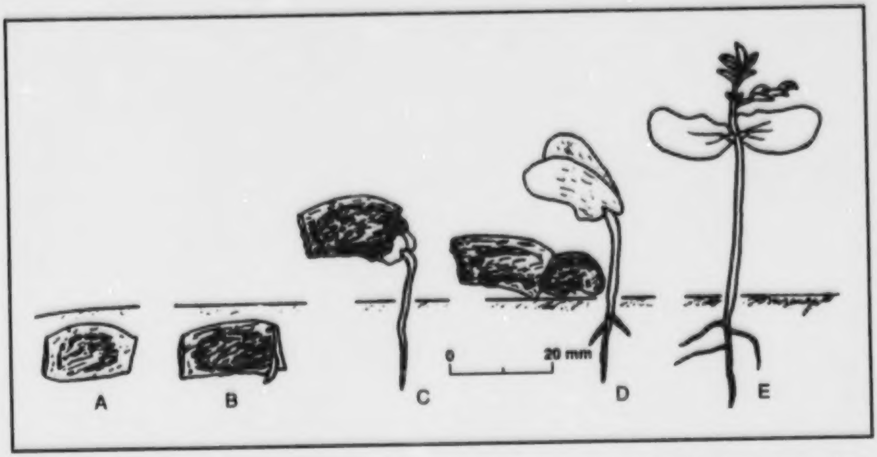


Figure 74. **Stages in seed germination and early development of *Dalbergia melanoxylon* seedlings. (A)** At sowing, **(B)** at 7 days, **(C)** at 10 days, **(D)** at 15 days, **(E)** at 25 days after sowing.

Deinbollia borbonica Scheff.

SAPINDACEAE

Other names

Mbwakambwaka, mwakamwaka (Kiswahili); mpwakampwaka (Kidigo).

Fruit morphology and seed extraction

The fruit is berry-like, rounded, and about 1.5 cm in diameter; it contains one seed. The skin and pulp are removed by macerating in water and then squashing by hand. The seeds are cleaned by washing in water. About 4 kg of fruits produce 1 kg of clean seeds.

Seed morphology

The seed is rounded, about 0.8 cm in diameter, and greyish brown, with an inconspicuous aril at the base. There are about 3500 seeds per kilogram.

Seed storage

The seed is intermediate between orthodox and recalcitrant, and can retain viability for up to one year at room temperature.

Seed presowing treatment

The seed does not need any pretreatment.

Seed germination

Germination is hypogeal (Figure 75), commencing with the emergence of the white radicle at the scar end. The cotyledonary stalks elongate, and the epicotyl pushes itself between them and develops into the seedling stem. The cotyledons are left within the seed coat and remain within the germination medium, attached to the seedling.

Germination is very good and fast. It reaches 80% after 12 days and 97% after 16 days from sowing.

Plant uses

The fruits are eaten by people and are much favoured by birds, while flowers provide bee forage. Liquid obtained from the boiled roots is used to treat hernias.

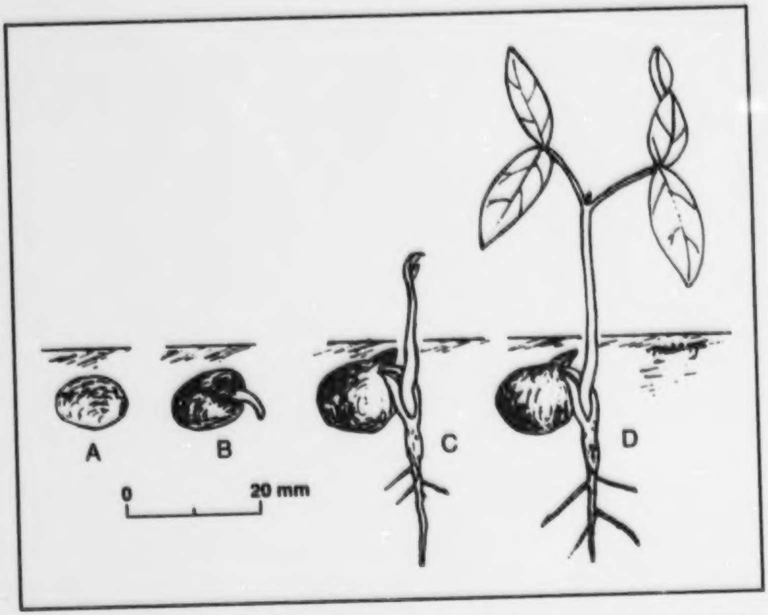


Figure 75. **Stages in seed germination and early development of *Deinbollia borbonica* seedlings. (A)** At sowing, **(B)** at 5 days, **(C)** at 10 days, **(D)** at 14 days after sowing.

Delonix elata (L.) Gamble

LEGUMINOSAE: CAESALPINIOIDEAE

Other names

Misele, mfausiku (Kiswahili); mlele (Kinyamwezi); mseele (Kigogo).

Fruit morphology and seed extraction

The fruit is a flat woody pod up to 20 cm long and 3 cm broad; it is dark brown when ripe, and breaks open to release up to 14 seeds (Figure 76). Dry pods are threshed in a gunny bag using a stick, and the seeds are cleaned by shaking and winnowing. A flailing thresher can also be used. About 10 kg of fruits produce 1 kg of seeds.

Seed morphology

The seed is slightly flattened and hard, with rounded ends, about 1.5 cm long and 0.7 cm broad; it is shiny and brown with patches of grey. There are about 3700 seeds per kilogram.

Seed storage

The seed is orthodox and can be stored up to three years at room temperature without significant loss of viability, if kept dry and free of insects.

Seed presowing treatment

Bulk quantities of seed should be pretreated by the hot water method. Small quantities may be pretreated using a hot wire (*see* section on seed presowing treatments).

Seed germination

Germination is epigeal (Figure 77). The seed coat ruptures and the vigorous white radicle emerges. The hypocotyl elongates, and carries the cotyledons above the germination medium. The seed coat is either left in the germination medium or carried up by the cotyledons until they unfold and the seed coat falls off.

Germination is very good and uniform, attaining 40% after 10 days and 90% after 15 days from sowing.

Plant uses

The tree provides firewood, bee forage and fodder. It is an attractive ornamental, with large, beautiful, yellow flowers.

Figure 76. *Delonix elata* pod and seeds.

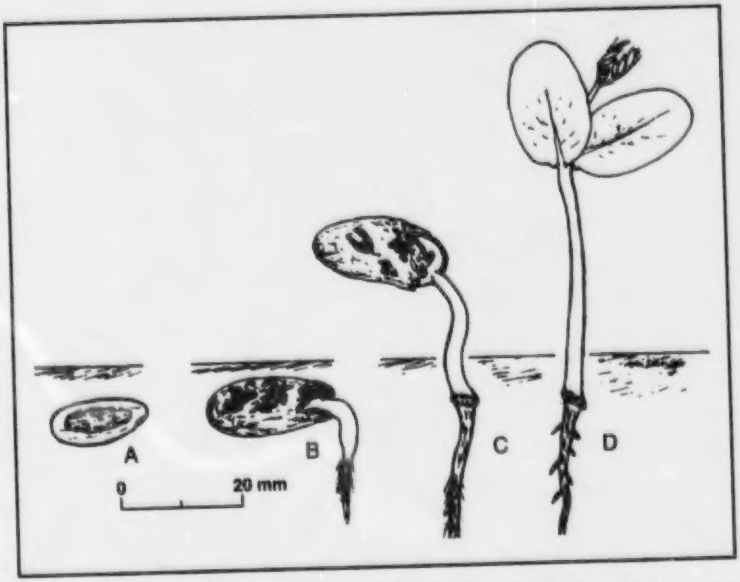


Figure 77. Stages in seed germination and early development of *Delonix elata* seedlings. (A) At sowing, (B) at 4 days, (C) at 7 days, (D) at 10 days after sowing.

Dichrostachys cinerea (L.) Wight & Arn.

Syn. *Dichrostachys glomerata* (Forssk.) Chiov.

LEGUMINOSAE: MIMOSOIDEAE

Other names

Lantern tree; mkulagembe (Kizaramo); mtunduru (Kiswahili, Kinyamwezi); mchelegembe (Kisambaa); sagha (Kipare).

Fruit morphology and seed extraction

The fruit is a pod, dark brown when mature, about 10 cm long, twisting to form bundles which may remain on the tree for a long period; pods contain approximately four seeds each. Ripe pods may be picked from trees and dried in the sun. Alternatively, pods may be picked from the ground soon after natural shedding or after shaking the tree.

The pods are heaped on a tarpaulin or other sheeting material and beaten well with sticks to detach the seeds from the valves; the seeds are then cleaned by shaking and winnowing. For extraction of bulk quantities of seeds, a flailing thresher and an air-screen cleaner may be used (as for *Acacia nilotica*). About 6 kg of pods produce 1 kg of seeds.

Seed morphology

The seed is about 5 mm long and 4 mm wide, almost round, and slightly flattened or compressed. On each of the two flat sides there is a light line, which follows roughly the outline of the seed. The seed is brown and shiny, with a hard seed coat. There are about 18 000 seeds per kilogram.

Seed storage

The seed is orthodox and can be stored for five years at room temperature without significant loss of viability, if kept dry and free of insects.

Seed presowing treatment

Small quantities may be pretreated using a hot wire. For bulk quantities, the seed gun may be used at a speed which will give a crack index of about 50%. Hot water and boiling treatments are also appropriate for this species. For the boiling treatment, the suggested immersion period is three minutes (*see* section on seed presowing treatments).

Seed germination

Germination is epigeal (Figure 78). The radicle emerges first, then the hypocotyl elongates, bending, and carries the cotyledons above the germination medium. The seed coat usually remains partially enclosing the cotyledons until they split and it falls off. The cotyledons change colour from white to green, later becoming brown and shrivelled. The first leaf is compound with seven pairs of leaflets.

Germination is very good after pretreatment. It reaches 45% after seven days and 90% after 15 days from sowing.

Plant uses

The pods are a valuable source of livestock feed when they ripen and fall during the dry season. The stem and branches are used for firewood, and for building livestock folds. The timber is hard and durable, and is used for tool handles. Chewed roots are used as a topical antidote for scorpion stings or snake bites, while chewed leaves are used as a local anaesthetic. A liquid obtained from boiled roots of this species, together with *Ximenia americana* and *Zanthoxylum chalybeum*, is drunk as a treatment for gonorrhoea.

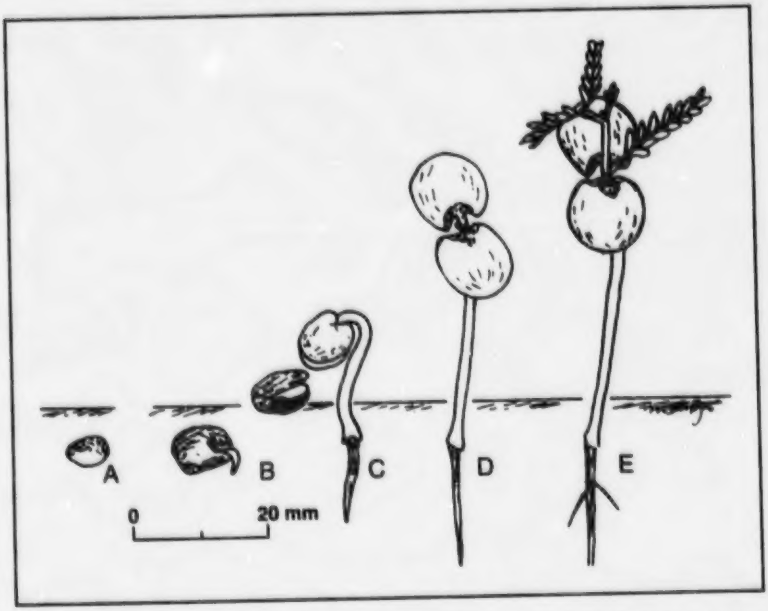


Figure 78. **Stages in seed germination and early development of *Dichrostachys cinerea* seedlings. (A)** At sowing, **(B)** at 4 days, **(C)** at 7 days, **(D)** at 10 days, **(E)** at 20 days after sowing.

Diospyros kirkii Hiern

EBENACEAE

Other names

Mnumbulu (Kinyamwezi).

Fruit morphology and seed extraction

The fruit is a spherical berry, up to 2.5 cm in diameter, greenish and hairy when young, and yellowish and smooth when ripe. Its base is enveloped in a cup-shaped structure with five backward-curling segments. The ripe fruits are picked from trees or collected from the ground soon after natural shedding. The skin and pulp are removed with a knife and the seeds washed in water. The empty seeds float on the surface and are discarded. Seeds which sink to the bottom are retained as viable and dried in the sun for two days. About 5 kg of fruits produce 1 kg of seed.

Seed morphology

The seed is dark brown, shiny, about 15 mm long and 9 mm wide, bean-shaped, with a deep longitudinal groove on one side. The seed coat and endosperm are very hard. There are about 500 seeds per kilogram.

Seed storage

The seed is orthodox and can be stored for three years at room temperature without significant loss of viability if kept dry and free of insects.

Seed presowing treatment

No pretreatment has been tried, but soaking the seeds in cold water for 12 hours may shorten the germination period.

Seed germination

Germination is epigeal (Figure 79). The radicle emerges from the scar and develops into a vigorous taproot. The hypocotyl elongates and carries the seed coat and cotyledons above the germination medium. The cotyledons expand, split the seed coat, and change colour from white to green.

Germination is good and moderately uniform. It attains 10% after three weeks and 70% after six weeks from sowing.

Plant uses

The stem provides poles used in roofs of huts. The wood is used for making tool handles and charcoal.

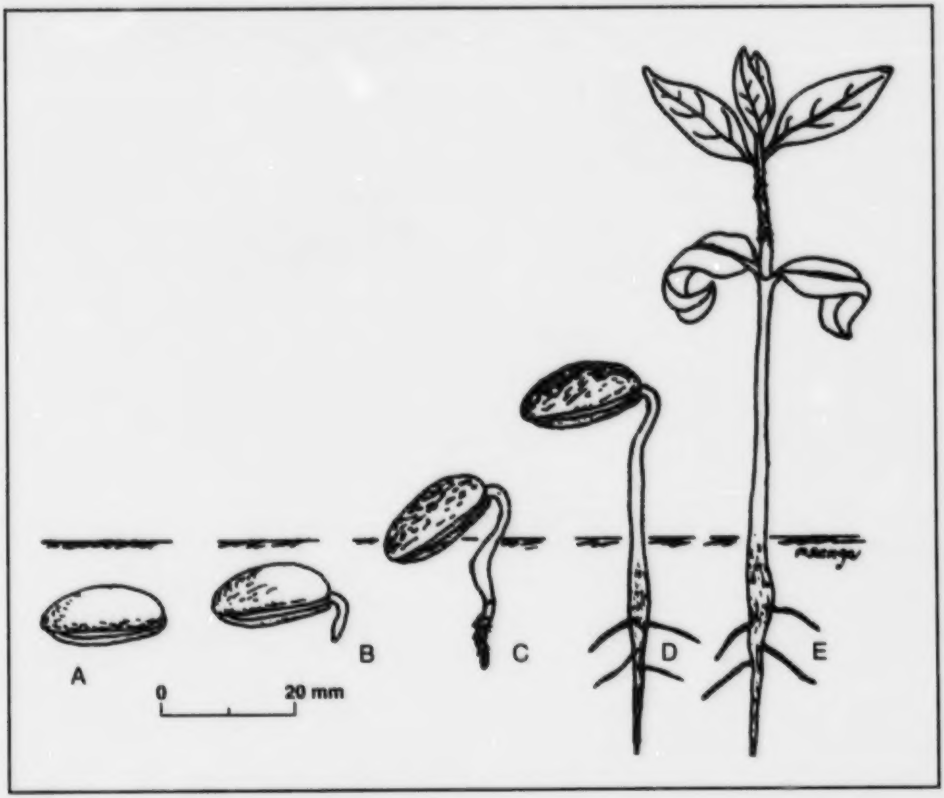


Figure 79. **Stages in seed germination and early development of *Diospyros kirkii* seedlings. (A)** At sowing, **(B)** at 15 days, **(C)** at 20 days, **(D)** at 25 days, **(E)** at 35 days after sowing.

Diospyros mespiliformis Hochst. ex A. DC.
EBENACEAE

Other names

African ebony; msinde (Kichaga, Kiluguru, Kinyamwezi); mjongolo (Kipare); mjohoro mpweke (Kiswahili).

Fruit morphology and seed extraction

The fruit is a round berry, up to 2.5 cm in diameter, greenish and hairy when young, and yellowish and smooth when ripe. Each fruit contains up to five seeds. The ripe fruits are picked from trees or collected from the ground soon after natural shedding. The skin and pulp are removed with a knife and the seeds washed in water. The empty seeds float, and are discarded. Seeds which sink are retained and dried in the sun for two days. About 5 kg of fruits produce 1 kg of seed.

Seed morphology

The seed is about 10 mm long and 7 mm wide, bean-shaped, dark brown and shiny, with a deep longitudinal groove on one side. The seed coat and endosperm are very hard. There are about 2000 seeds per kilogram.

Seed storage

The seed is orthodox, and can be stored for three years at room temperature without significant loss of viability if kept dry and free of insects.

Seed presowing treatment

No pretreatment has been tried, but soaking the seeds in cold water for 12 hours may shorten the germination period.

Seed germination

Germination is epigeal (Figure 80). The radicle emerges at the scar and develops into a vigorous taproot. The hypocotyl elongates, bending greatly, and carries the seed coat and cotyledons above the germination medium. The cotyledons expand, split the seed coat, and change colour from white to green.

Germination is very good and moderately uniform. It attains 40% after three weeks and 90% after six weeks from sowing.

Plant uses

The stem provides poles used in roofs of huts. The wood is resistant to termites and is used for making tool handles, gun stocks, and furniture. The fruit has a sweet edible pulp and it is dried and stored for use during times of food shortage. The fruit is also used in making a local brew.

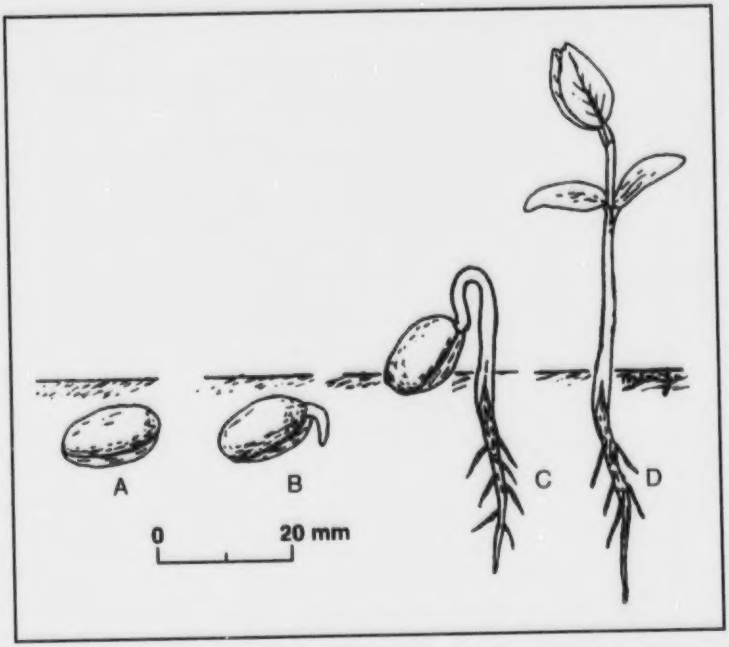


Figure 80. Stages in seed germination and early development of *Diospyros mespiliformis* seedlings. (A) At sowing, **(B)** at 5 days, **(C)** at 10 days, **(D)** at 15 days after sowing.

Diospyros zombensis (B.L. Burtt) F. White

Syn. *Royena amnicola* B.L. Burtt

EBENACEAE

Other names

Mjongolo (Kipare).

Fruit morphology and seed extraction

The fruit is a round berry, up to 2.5 cm in diameter, greenish and hairy when young, and yellowish and smooth when ripe. Each fruit contains up to five seeds. The ripe fruits are picked from trees or collected from the ground soon after natural shedding. The skin and pulp are removed using a knife and the seeds washed in water. The empty seeds float, and are discarded. Seeds which sink are retained and dried in the sun for two days. About 5 kg of fruits produce 1 kg of seeds.

Seed morphology

The seed is about 15 mm long and 9 mm wide, dark brown, and almost egg-shaped, with a deep longitudinal groove on one side. The seed coat and endosperm are very hard. There are about 500 seeds per kilogram.

Seed storage

The seed is orthodox, and can be stored for three years at room temperature without significant loss of viability if kept dry and free of insects.

Seed presowing treatment

No pretreatment has been tried, but soaking in cold water for 12 hours may shorten the germination period.

Seed germination

Germination is epigeal (Figure 81). The radicle emerges at the scar and develops into a vigorous taproot. The hypocotyl elongates and carries the seed coat and cotyledons above the germination medium. The cotyledons split the seed coat and change colour from white to green.

Germination is fair but sporadic, attaining 5% after three weeks and 55% after six weeks from sowing.

Plant uses

The stem provides poles used for hut roofs. The roots are used in the preparation of traditional medicines.

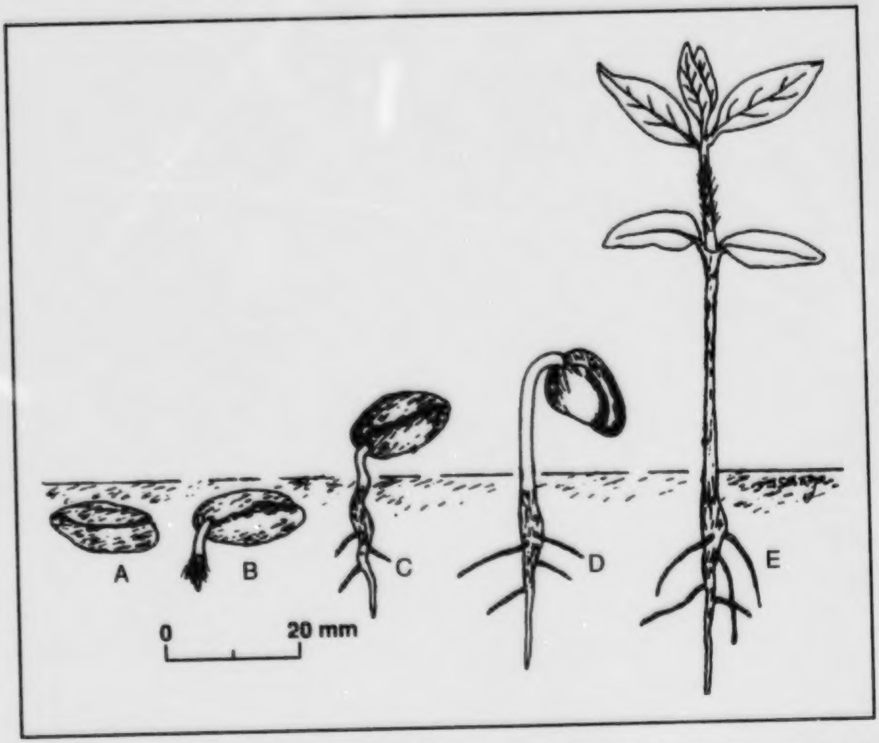


Figure 81. **Stages in seed germination and early development of *Diospyros zombensis* seedlings. (A)** At sowing, **(B)** at 15 days, **(C)** at 25 days, **(D)** at 30 days, **(E)** at 35 days after sowing.

Dodonaea viscosa Jacq.
SAPINDACEAE

Other names

Sand olive, hopbush; njitwe (Kipare); mzutwe (Kisambaa).

Fruit morphology and seed extraction

The fruits are roundish capsules up to 2 cm in diameter, with two or three winged compartments; the membraneous, pale yellow wings become purplish red as they mature. Fruit remain on the tree for a long period. Ripening fruits are collected from the trees, and drying is completed in the sun. They require hard flailing and frequent shaking to release seed. About 8 kg of fruits produce 1 kg of seeds.

Seed morphology

The seed is about 2 mm in diameter, nearly spherical, with a hole near the scar, and is black, with a smooth, hard seed coat. There are about 90 000 seeds per kilogram.

Seed storage

The seed is orthodox, and can be stored for three years at room temperature without significant loss of viability if kept dry and free of insects.

Seed presowing treatment

Seed should be soaked in cold water for 12 hours.

Seed germination

Germination is epigeal (Figure 82). The seed coat softens as the seed absorbs water. The cotyledons swell and rupture the seed coat at the scar, and the radicle emerges and elongates. The hypocotyl elongates, bending slightly, and carries the seed coat with the cotyledons above the germination medium. The cotyledons enlarge greatly and split the seed coat, which later falls off.

Germination is good and uniform. It attains 20% after two weeks and 70% after three weeks from sowing day.

Plant uses

A water solution obtained from pounded leaves is used medicinally to treat skin diseases, fever, sore throats, influenza, chest complaints, stomach disorders, and cancer. The leaves have anaesthetic properties, and act as a stimulant when chewed. The twig is used as a toothbrush. The plant is decorative, and used in hedges. Other uses for this tree include sand and soil stabilization, firewood, tool handles and walking sticks.

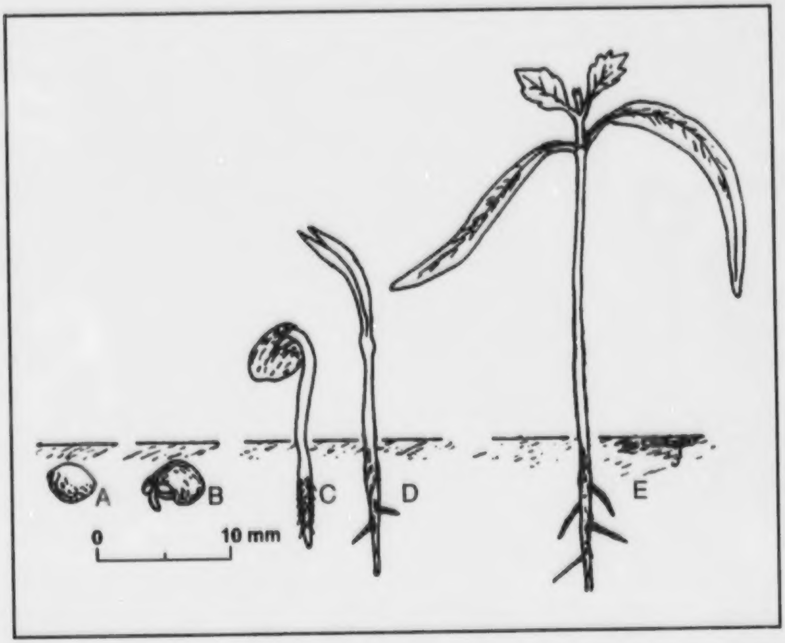


Figure 82. **Stages in seed germination and early development of *Dodonaea viscosa* seedlings. (A)** At sowing, **(B)** at 5 days, **(C)** at 10 days, **(D)** at 15 days, **(E)** at 30 days after sowing.

Ekebergia capensis Sparrm.

Syn. *Ekebergia rueppeliana* (Fresen.) A. Rich.

MELIACEAE

Other names

Dog plum; mfuare, mroboki (Kichaga); musimbi (Kihaya); monko (Kisambaa); mvumba (Kigogo).

Fruit morphology and seed extraction

The fruit is an almost spherical berry, up to 2 cm diameter, becoming yellow-red when ripe. The outer skin is thin and encloses a white, soft pulp containing two to four seeds. The fruit skin and pulp are removed by macerating in water and squashing by hand. The seeds are cleaned by washing in water. About 5 kg of fruits produce 1 kg of seeds.

Seed morphology

The seed is rounded at one end and beaked, or pointed, at the other, with a transverse scar. It is 1.5 cm long and 0.7 cm broad, creamy white, and has a rather hard, brittle seed coat. There are about 3000 seeds per kilogram.

Seed storage

The seed is recalcitrant and should be packed in small quantities (less than 5 kg) in cotton bags to provide good ventilation. They cannot tolerate a low moisture content or freezing temperatures. Seeds should be sown within four weeks after harvesting.

Seed presowing treatment

Germination of untreated seed is poor. Further research is required to improve germination.

Seed germination

Germination is epigeal (Figure 83). The seed coat cracks at the pointed end, then the radicle emerges and pushes its way downwards. The hypocotyl elongates, bending greatly, and carries the cotyledons above the germination medium.

Germination is good but delayed. It attains 37% after four weeks and 60% after six weeks from sowing.

Plant uses

The tree provides firewood, poles, timber, and shade, and can be planted as an ornamental. The roots are used to treat diarrhoea.

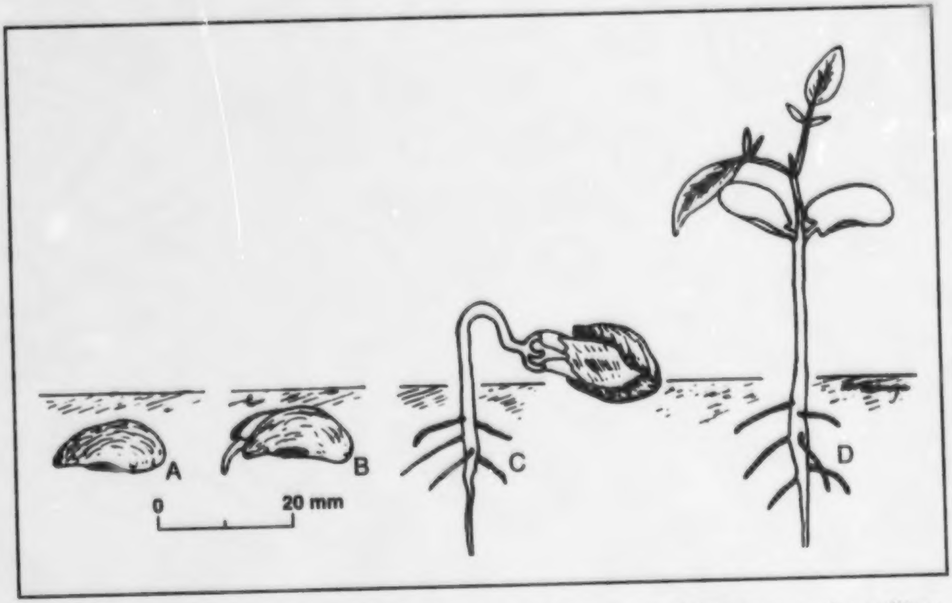


Figure 83. **Stages in seed germination and early development of *Ekebergia capensis* seedlings. (A)** At sowing, **(B)** at 1 week, **(C)** at 3 weeks, **(D)** at 4 weeks after sowing.

Entandrophragma bussei Engl.
MELIACEAE

Other names

Muwondo (Kigogo, Kinyamwezi).

Fruit morphology and seed extraction

The fruit is a woody capsule, greyish-brown, with many breathing-pores on the outside, about 18 cm long and 1 cm broad, and rounded at the tip. On drying it splits from the tip. It has many seeds attached to the central column. After opening, the capsules can be shaken to release seeds. About 10 kg of fruits produce 1 kg of seeds.

Seed morphology

The seed has a thin, brown, spongy layer on the surface and is narrowly winged on the side opposite the scar. The seed (without the wing) is nearly flat, about 1.8 cm long and 1.5 cm broad. There are about 1500 seeds per kilogram.

Seed storage

Seeds are intermediate between orthodox and recalcitrant. They should be kept in a cool dry place and sown within six months after collection.

Seed presowing treatment

The seed wing should be removed before sowing. Research is necessary to find pretreatment methods to improve germination.

Seed germination

Germination is epigeal (Figure 84). The spongy layer and the wing absorb water. The radicle emerges first, followed by the short, stout hypocotyl, which carries the two thick cotyledons above the ground.

Germination is good and uniform, but somewhat delayed, reaching 30% after three weeks and 70% after four weeks from sowing.

Plant uses

The timber is used for building and furniture.

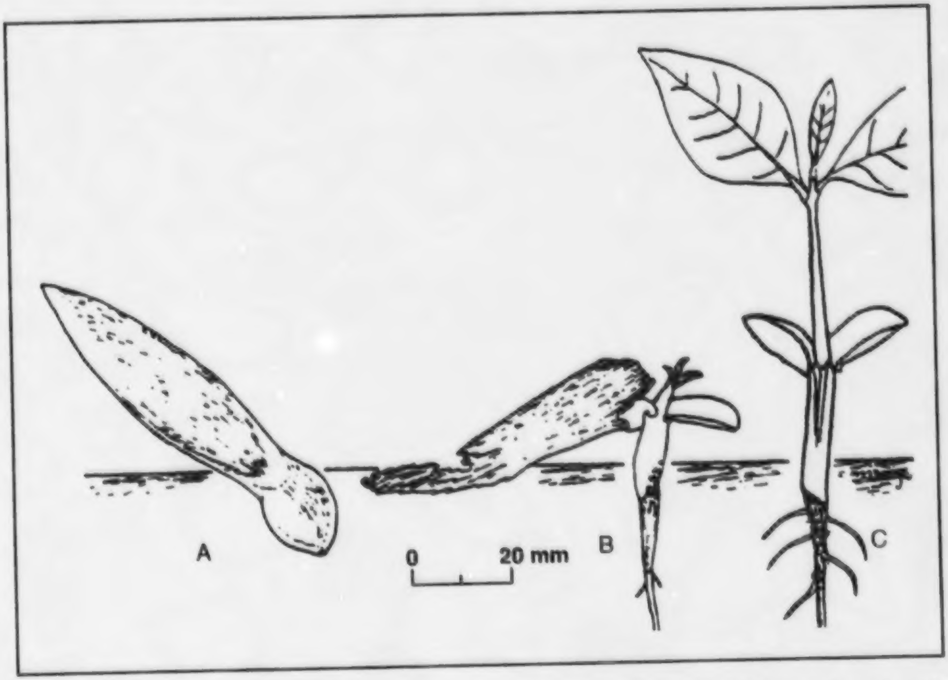


Figure 84. Stages in seed germination and early development of *Entandrophragma bussei* seedlings. (A) At sowing, (B) at 3 weeks, (C) at 4 weeks after sowing.

Entandrophragma excelsum (Dawe & Sprague) Sprague
MELIACEAE

Other names

Mbokoboko (Kisambaa); muovu (Kifipa).

Fruit morphology and seed extraction

The fruit is a woody capsule, opening in five sections, dark brown when ripe, about 15 cm long and 3 cm wide. Ripening fruits are collected from the trees and drying is completed in the sun. On drying, the fruit splits from the tip; the sections may break away from the base. The seeds are attached near the tip and are winged towards the base of the capsule. After opening, the capsules may be shaken to release the seeds. Alternatively, seeds may be collected from the ground soon after natural shedding. About 10 kg of fruits produce 1 kg of seeds.

Seed morphology

The seed has a thin, brown spongy layer on the surface and is narrowly winged on the side opposite the scar (Figure 85). The length, including wing, is variable, usually 8 to 10 cm, but may reach 14 cm. On removal of the wing and spongy layer, the seed is almost flat, about 2.5 cm long and 1.5 cm broad, brown, with a thin delicate seed coat. There are about 1200 winged seeds per kilogram.

Seed storage

Seeds are intermediate between orthodox and recalcitrant, and should be kept in a cool (2–5°C), dry place. Where such conditions are not available, seeds can be kept at ambient air temperature but out of direct sunshine. Seeds should be sown within 6 months after collection.

Seed presowing treatment

No pretreatment is required, but the wings should be broken off.

Seed germination

Germination is epigeal (Figure 86). The spongy layer and wing absorb and retain moisture. The radicle emerges through, or near, the scar and pushes its way downwards. The hypocotyl elongates and carries the cotyledons and seed coat above the germination medium. The cotyledons expand slightly and split one side of the enclosing spongy layer. The young shoot bends as it elongates and pushes its way between the cotyledons, through the split.

Germination is very good and uniform. It attains 30% after four weeks and 80% after six weeks from sowing.

Plant uses

The timber is used for building and furniture. The stem is clear and straight, which makes the tree important for plywood manufacture. In the montane forest the tree grows along streams, and the root system offers protection to streambanks. It can be planted in banana and coffee farms, and also as an avenue or ornamental tree.

Figure 85. *Entandrophragma excelsum* seeds.

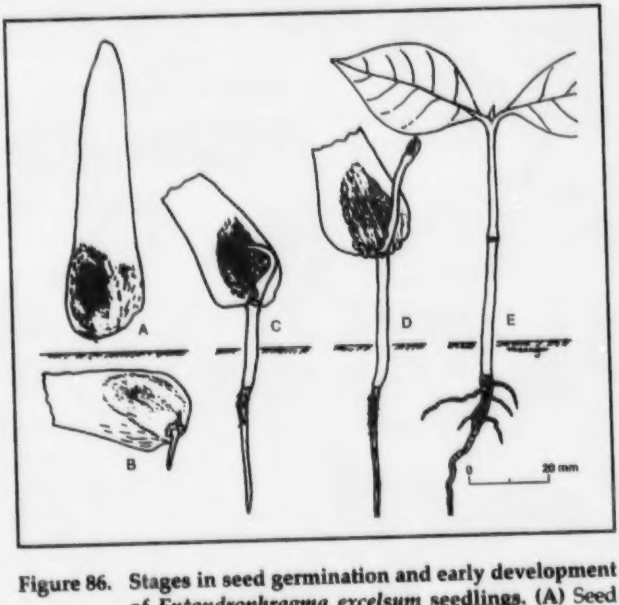


Figure 86. Stages in seed germination and early development of *Entandrophragma excelsum* seedlings. (A) Seed before sowing, (B) at 15 days, (C) at 30 days, (D) at 35 days, (E) at 45 days after sowing.

Erythrina abyssinica Lam. ex DC.
LEGUMINOSAE: PAPILIONOIDEAE

Other names

Red-hot-poker tree; mwambangoma, mjafari (Kiswahili); muungu (Kipare); mlungu (Kisambaa); mbundi (Kiluguru).

Fruit morphology and seed extraction

The fruit is a small, light-brown pod, covered with short hairs, constricted between seed chambers, up to 14 cm long and 2 cm broad. At maturity it splits open; eight to ten seeds line the edge of the pod. Seeds fall off after a few days. Ripening pods are collected from the tree and drying is completed in the sun. After opening, the pods are flailed and shaken to release seeds. A flailing thresher and an air-screen cleaner may also be used (as for *Acacia nilotica*). Alternatively, seeds may be collected from the ground soon after natural shedding. About 10 kg of fruits produce 1 kg of seeds.

Seed morphology

The seed is egg-shaped or round, very hard, bright red with a black scar, and up to 1 cm long and 7 mm broad. There are about 3500 seeds per kilogram.

Seed storage

The seed is orthodox and can be stored for four years at room temperature, if kept dry and free of insects.

Seed presowing treatment

Small quantities may be pretreated using a hot wire (*see* section on seed presowing treatments). When large quantities are to be pretreated, the hot water treatment is appropriate, using hot (75°C), but not boiling, water.

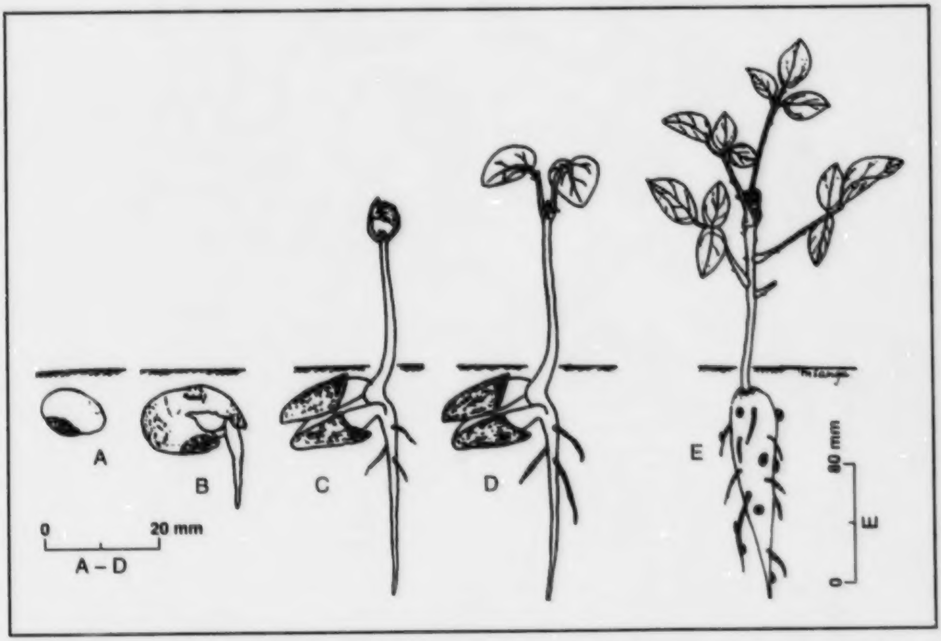
Seed germination

Germination is hypogeal, commencing with the bursting of the seed coat and elongation of the cotyledonary stalks (Figure 87). The thick whitish radicle emerges and develops into a taproot. The epicotyl develops between the cotyledonary stalks while the cotyledons remain in the germination medium.

Germination is very good and uniform if seeds are sown in sand. Seeds sown on blotting or filter paper give poor germination (about 45%).

Plant uses

The wood is used in wagon brake linings, and for making traditional stools, drums, mortars and beehives. The tree is attractive and suitable for ornamental planting, owing to the bright red flowers. The seedlings produce many root nodules (Figure 87), indicating its suitability for biological nitrogen fixation in agroforestry systems. The seeds are strung into necklaces and sold as curios. The bark is used to treat prolonged cough, gonorrhoea, and snake bite. Pounded roots are used for treating malaria, anthrax, syphilis and snake bite.


A
B
C
D
E
0
20 mm
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80 mm
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0

Figure 87. **Stages in seed germination and early development of *Erythrina abyssinica* seedlings.** **(A)** At sowing, **(B)** at 5 days, **(C)** at 10 days, **(D)** at 15 days, **(E)** 3-month-old seedling with profuse nodules.

Erythrina burttii Baker f.

LEGUMINOSAE: PAPILIONOIDEAE

Other names

Mtuti (Kigogo); ngaroji (Kimasai); mbukwe (Kipare).

Fruit morphology and seed extraction

The fruit is a light-brown dehiscent pod, up to 6 cm long and 2 cm broad, and constricted between seed chambers. There are up to five seeds in each pod. Ripening pods are collected from the tree and drying is completed in the sun. After opening the pods are heaped and beaten with a stick to release seeds, or a flailing thresher and an air-screen machine may be used (as for *Acacia nilotica*). About 15 kg of fruits produce 1 kg of seeds. Alternatively, seeds may be collected from the ground soon after natural shedding.

Seed morphology

The seed is kidney-shaped, with rounded tips, a hard orange seed coat, and a black scar. It is about 1.5 cm long and 0.7 cm broad. There are about 2500 seeds per kilogram.

Seed storage

The seed is orthodox and can be stored for up to three years at room temperature without significant loss of viability, if kept dry and free of insects.

Seed presowing treatment

Small quantities may be pretreated using a hot wire (*see* section on seed presowing treatments). When large quantities are to be pretreated, the hot water treatment is appropriate, using hot (75°C), but not boiling, water.

Seed germination

Germination is epigeal (Figure 88). The seed coat softens as the seed absorbs water. The cotyledons swell greatly and rupture the seed coat at the scar, and the radicle emerges and develops into a vigorous taproot. The hypocotyl elongates and rises above the germination medium. The cotyledons open and release the developing primary leaves.

Germination is good and uniform. It reaches 40% after seven days and 60% after 14 days from sowing.

Plant uses

The wood is used for making traditional stools, drums, mortars and beehives. The tree is attractive and ornamental, with a flat-topped crown and bright red flowers. The tree is suitable for biological nitrogen fixation in agroforestry systems.

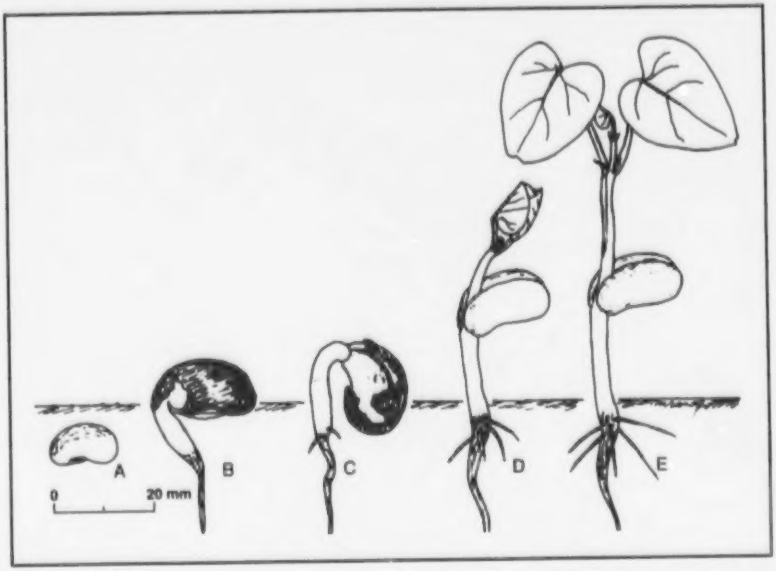


Figure 88. Stages in seed germination and early development of *Erythrina burttii* seedlings. (A) At sowing, **(B)** at 4 days, **(C)** at 5 days, **(D)** at 7 days, **(E)** at 10 days after sowing.

Excoecaria bussei (Pax) Pax

Syn. *Sapium bussei* Pax

EUPHORBIACEAE

Other names

Mzejezeje (Kigogo); katongotongo (Kihehe); isusu (Kirangi).

Fruit morphology and seed extraction

The fruit is an indehiscent capsule, about 5 cm in diameter, and dry when ripe. Ripe fruits persist on the plant. Dry fruits are picked from trees. They can be broken into three parts and a seed extracted by hand from each. About 5 kg of fruit produce 1 kg of seeds.

Seed morphology

The seed is rounded, about 1 cm across, and brown, with a brittle seed coat. There are about 1800 seeds per kilogram.

Seed storage

Seeds are intermediate between orthodox and recalcitrant, and should be kept in a cool (2–5°C), dry place. Where such conditions are not available, seeds can be kept at ambient air temperature but out of direct sunshine. Seeds should be sown within six months after collection.

Seed presowing treatment

The seed does not require any pretreatment.

Seed germination

Germination is epigeal (Figure 89). The seed coat cracks, starting at the scar point. The radicle protrudes and develops into a taproot. The hypocotyl bends greatly as it elongates, and carries the seed coat up on the cotyledons, which expand, split apart and change colour from white to green.

Germination is very good and moderately uniform. It attains 70% after ten days and 100% after 20 days from sowing.

Plant uses

The leaves and seeds are used in the preparation of traditional medicines. The latex causes temporary blindness, while both latex and crushed seeds are poisonous to human skin.

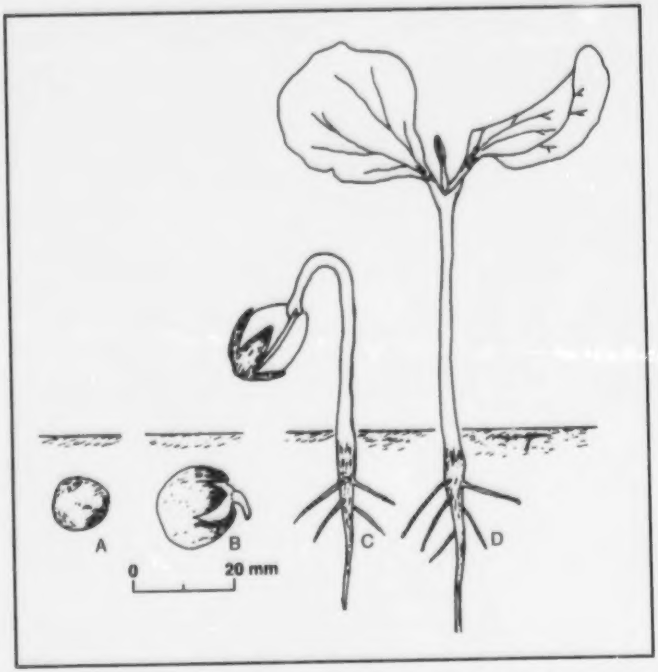


Figure 89. Stages in seed germination and early development of *Excoecaria bussei* seedlings. (A) At sowing, **(B)** at 5 days, **(C)** at 20 days, **(D)** at 25 days after sowing.

Faidherbia albida **(Delile) A. Chev.**

Syn. *Acacia albida* Delile

LEGUMINOSAE: MIMOSOIDEAE

Other names

Apple-ring acacia, ana tree; mkababu, mgunga (Kiswahili); mkambabu (Kipare).

Fruit morphology and seed extraction

The fruit is a rather thick pod, orange-yellow when dry, indehiscent, up to 4 cm wide, and contorted, curved or spirally twisted (Figure 90). Ripe, dry pods are picked from standing trees or collected from the ground soon after natural shedding. Pods are dried in the sun and broken by hand or pounded in a mortar to extract the seeds. The seeds are separated from the broken pods by shaking and winnowing. For extraction of bulk quantities of seeds a flailing thresher and air-screen cleaner may be used (as for *Acacia nilotica*). About 11 kg of pods produce 1 kg of clean seeds.

Seed morphology

The seeds are egg-shaped, about 9 mm long and 4 mm broad, light brown, and compressed, with a hard seed coat. The flat faces are marked by a line parallel to the outline of the seed. There are about 8700 seeds per kilogram.

Seed storage

The seed is orthodox and can be stored for three years at room temperature without significant loss of viability, if kept dry and free of insects.

Seed presowing treatment

When dealing with small quantities, the seeds can be pretreated by using a hot wire (*see* section on seed presowing treatments). When bulk quantities are pretreated, the seed gun may be used at a speed which will give a crack index of about 40%. Either the hot water or boiling treatment may be used. For the boiling treatment, an immersion period of three minutes is advised.

Seed germination

Germination is epigeal (Figure 91). The radicle emerges from the scar end, while the hypocotyl elongates and carries the cotyledons above the germination medium. The seed coat usually remains partially enclosing the cotyledons until they expand. The cotyledons have small, sessile, ear-like lobes at the base. The first two leaves are bipinnate, each with one pair of pinnae and a pair of scale-like appendages, or stipules, at the base of the stalk.

Germination is very good and uniform after pretreatment, reaching 50% after five days and 95% after 14 days from sowing.

Plant uses

The tree is suitable for intercropping with agricultural crops, owing to its nitrogen-fixing ability and its unusual habit of remaining leafless during the rains; the tree assumes new foliage and flowers only at the beginning of the dry season. The wood is used for making boxes, shuttering and cheap joinery, while the pods and leaves provide valuable livestock and game feed. The green pods are used for stupefying fish. The bark is boiled and the liquid drunk to cure diarrhoea. The tree also provides firewood, tannin, dyes, mulch, fence posts, gum, veterinary and human medicines.

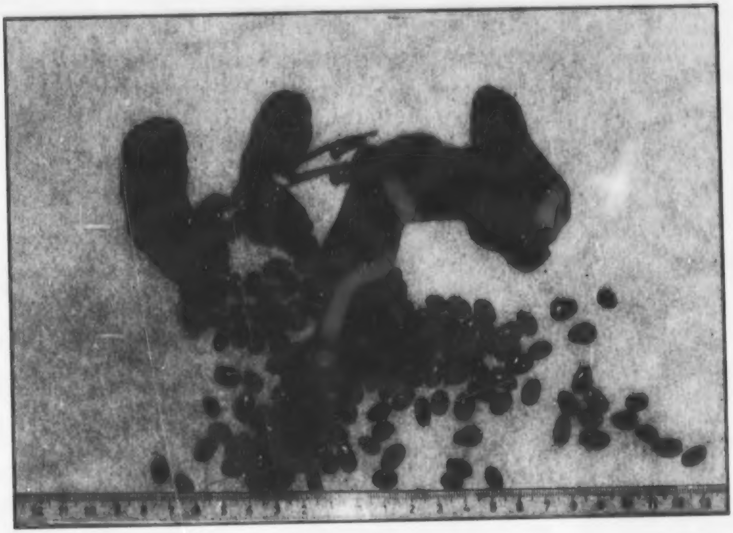


Figure 90. *Faidherbia albida* pods and seeds.

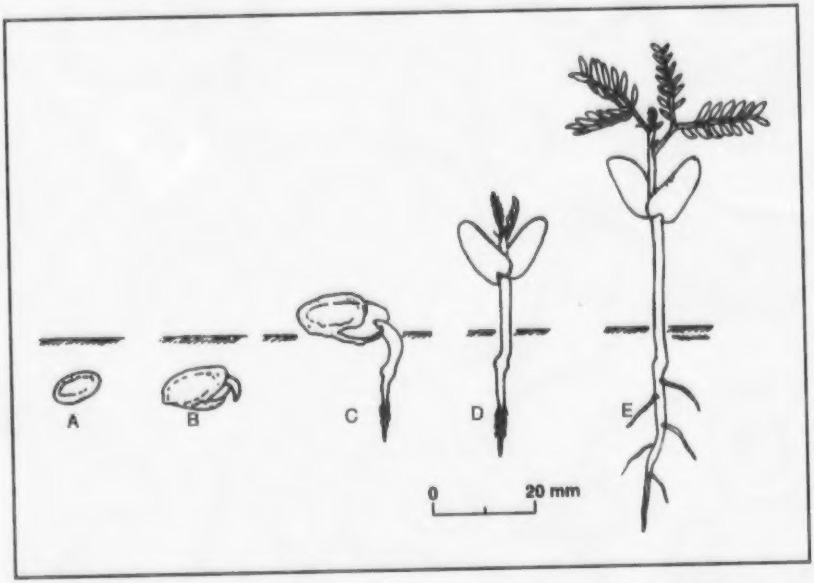


Figure 91. Stages in seed germination and early development of *Faidherbia albida* seedlings. (A) At sowing, (B) at 2 days, (C) at 4 days, (D) at 7 days, (E) at 25 days after sowing.

***Ficus sur* Forssk.**
Syn. *Ficus capensis* Thunb.
MORACEAE

Other names

Fig tree; mkuyu (Kiswahili, Kigogo, Kinyamwezi, Kirangi); njombe (Kihehe); olgnangboli (Kimasai).

Fruit morphology and seed extraction

The fruit is a round fig, up to 4 cm in diameter, green when young; turning red, mottled with pink. It has many minute seeds. The fruits are squashed by hand to squeeze the seeds out of the pulp. When immersed in water, the pulp, fruit skin and empty seeds float, and can be poured off, leaving clean filled seeds. About 80 kg of fruits produce 1 kg of seeds.

Seed morphology

The seed is very small, spherical, about 1 mm across, and creamy white. There are about 900 000 seeds per kilogram. This is the smallest seed of all indigenous trees of Tanzania.

Seed storage

Seeds are intermediate between orthodox and recalcitrant, and should be kept in a cool, dry place. They should be sown within one year.

Seed presowing treatment

The seed does not need any pretreatment.

Seed germination

Germination is epigeal (Figure 92). The radicle protrudes and descends. The hypocotyl elongates and carries the seed coat up on the cotyledons; later the seed coat falls off as the leafy cotyledons enlarge.

Germination is very good and uniform. It attains 30% after two weeks and 95% after three weeks from sowing.

Plant uses

The fruits are eaten fresh in times of food shortage. The latex is used to relieve toothache. The wood is used for making traditional drums, while sticks from the tree are used to produce fire by friction. The tree can be intercropped with bananas and coffee. The fig tree is one of the sacred trees of Tanzania, and many traditional ceremonies are conducted under it. These may include sacrifices of animals such as goats or black sheep to satisfy ancestral spirits, to bring rain, to relieve famine and to protect against epidemics or other calamities.

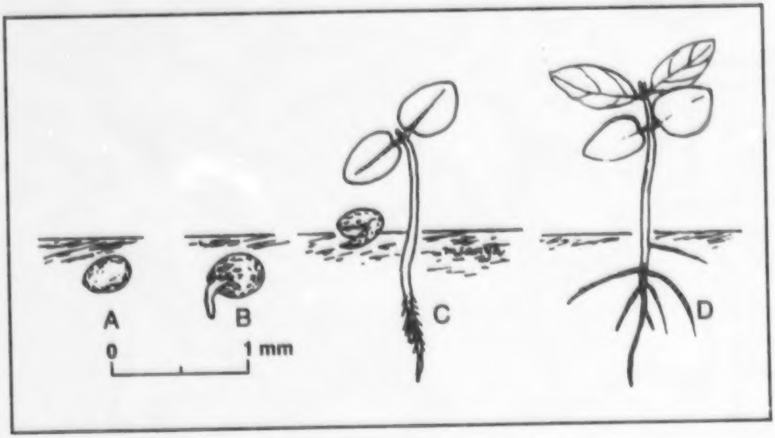


Figure 92. Stages in seed germination and early development of *Ficus sur* seedlings. (A) At sowing, **(B)** at 7 days, **(C)** at 10 days, **(D)** at 30 days after sowing.

Garcinia livingstonei T. Anderson

GUTTIFERAE

Other names

African mangosteen; mpekeso (Kiswahili).

Fruit morphology and seed extraction

The fruit is a capsule, about 3.5 cm in diameter, almost spherical, yellow to orange when ripe, and containing two seeds. The skin and pulp are removed by macerating in water and then squashing by hand. The seeds are washed in water. About 5 kg of fruits produce 1 kg of seeds.

Seed morphology

The seed is fleshy, 2.5 cm long and 1.3 cm broad, with rounded ends. The seed coat is light brown, thin, and streaked with strands of ducts resembling a network of fibres. There are about 150 seeds per kilogram.

Seed storage

The seed is recalcitrant, and should not be dried in the sun or stored at freezing temperatures. Seeds should be packed in small quantities (less than 5 kg) in cotton bags to provide ventilation, and should be sown within six weeks after collection.

Seed presowing treatment

The seed does not require pretreatment.

Seed germination

Germination is hypogeal (Figure 93). It commences with the emergence of the white radicle at the scar end, then the shoot appears just above the radicle. The epicotyl gives rise to a scaly stem. One or sometimes many adventitious roots soon differentiate at the stem base and grow to form the final root system. The base of the stem is enclosed by a short tube formed by the united cotyledonary stalks.

Germination is very good and moderately uniform, but delayed. It reaches 80% after five weeks and 90% after seven weeks from sowing.

Plant uses

The fruit pulp is edible. The heartwood is suitable for furniture, and the tree produces high quality firewood. The tree has attractive, shiny leaves and sweet-smelling, creamy-green flowers, which make it a useful ornamental.

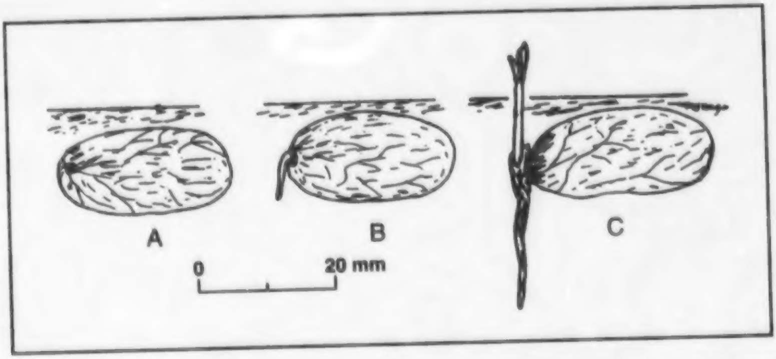


Figure 93. **Stages in seed germination and early development of *Garcinia livingstonei* seedlings. (A)** At sowing, **(B)** at 4 weeks, **(C)** at 5 weeks after sowing.

Gardenia ternifolia Schumach. & Thonn. subsp. *jovis-tonantis* (Welw.) Verdc.

RUBIACEAE

Other names

Kivarivari (Kipare); mtulankondo (Kiswahili); geninyet (Kimasai).

Fruit morphology and seed extraction

The fruit is an irregularly formed berry, round or elongated, hard, sometimes as large as a duck's egg, with rough grey-green skin, distinct breathing pores and many seeds. Fruit persist on the tree for a long time. Seeds are extracted by splitting the fruit with a knife and squashing by hand. When mixed with water, the pulp, skin, and empty seeds float and can be poured off, leaving clean filled seeds.

Seed morphology

The seed is flat, round, about 6 mm in diameter, and creamy white. There are about 43 000 seeds per kilogram.

Seed storage

Seeds are intermediate between orthodox and recalcitrant, and can be stored at room temperature for one year without significant loss in viability.

Seed presowing treatment

The seed does not require pretreatment.

Seed germination

Germination is epigeal (Figure 94). The radicle protrudes from the scar end and develops into a taproot. The seed coat is carried up by the expanding hypocotyl on the leafy cotyledons, which expand greatly, and change colour from white to green.

Germination is very good but slow. It reaches 25% after four weeks and 85% after six weeks from sowing.

Plant uses

The wood is used for tool handles, and branches are used for food stirrers and fencing. The tree has medicinal value.

It is also planted in gardens as an ornamental due to its sweet-smelling, creamy-yellow or white flowers.

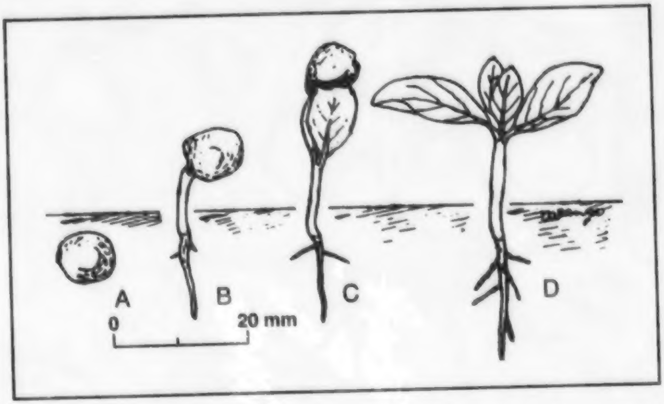


Figure 94. **Stages in seed germination and early development of *Gardenia ternifolia* seedlings. (A)** At sowing, **(B)** at 4 weeks, **(C)** at 5 weeks, **(D)** at 6 weeks after sowing.

Hagenia abyssinica (Bruce) J.F. Gmel.

ROSACEAE

Other names

Lengijabe (Kiarusha); mwanga, mwangala (Kichaga); liturunga (Kinyakyusa); mrosirose (Kisambaa).

Fruit morphology and seed extraction

The fruit is a small drupe with one seed, embedded in calyx-lobes and clustered along the panicles. These clusters of dry flowers are removed from the panicles by gently crushing them between the hands. The seeds are separated from chaff by winnowing. Alternatively, the seeds can be laboriously removed from the floral parts by hand.

Seed morphology

The seed is brown, net-veined, wrinkled and egg-shaped, with a thin fragile pericarp. It is small, about 1.5 mm across; there are about 400 000 seeds per kilogram.

Seed storage

Seeds are intermediate between orthodox and recalcitrant, and should be kept in a cool (2–5°C) dry place. Where such conditions are not available, seeds can be kept at ambient temperature but out of direct sunshine. Seeds should be sown within six months after collection.

Seed presowing treatments

The seed does not require pretreatment.

Seed germination

Germination is epigeal (Figure 95). The seed coat softens as the seed absorbs water. After about 10 days it ruptures as the radicle emerges through the scar side. The hypocotyl bends slightly as it elongates, and carries both the seed coat and cotyledons above the germination medium. Later the long-stalked cotyledons expand and separate and the seed coat falls off.

Germination is very good and uniform, attaining 60% after 15 days and 90% after 20 days from sowing.

Plant uses

The dried female inflorescences are boiled to produce a liquid which is taken as an anthelmintic. The wood is beautiful, and is used for furniture, cabinet-making and flooring. The stem and branches are used for tool handles and firewood.

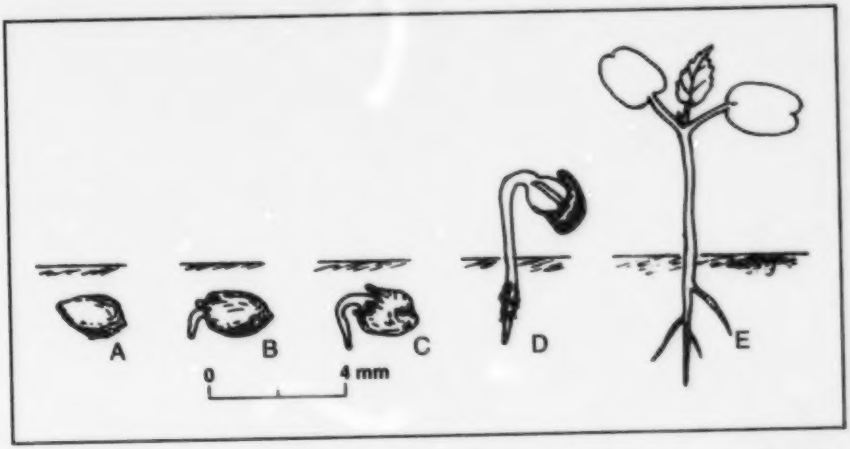


Figure 95. Stages in seed germination and early development of *Hagenia abyssinica* seedlings. (A) At sowing, **(B)** at 10 days, **(C)** at 15 days, **(D)** at 20 days, **(E)** at 25 days after sowing.

Jatropha curcas L.
EUPHORBIACEAE

Other names

Physic nut, purging nut; mkaburi (Kiswahili); mnyanga (Kinyamwezi).

Fruit morphology and seed extraction

The fruit is a woody, egg-shaped capsule, almost 3 cm diameter, and usually splitting into three parts. The ripe fruits are picked from the tree and drying is completed in the sun. When dry, the fruits split open explosively to release up to four seeds. Alternatively, seeds can be collected from the ground soon after natural shedding. About 4 kg of fruits produce 1 kg of seeds.

Seed morphology

The seed is slightly elongated with a caruncle at the base, about 15 to 20 mm long and 8 to 10 mm broad. It is dark grey with a brittle seed coat. There are about 1700 seeds per kilogram.

Seed storage

Seeds are intermediate between orthodox and recalcitrant, and should be kept in a cool (2–5°C) dry place. Where such conditions are not available, seeds can be kept at ambient air temperature but out of direct sunshine. Seeds should be sown within six months after collection.

Seed presowing treatment

No pretreatment is required, but light hammering to create fine cracks in the seed coat gives good results.

Seed germination

Germination is epigeal (Figure 96). The seed coat cracks and the radicle protrudes from the scar end. The seed coat is carried up on the cotyledons. The leafy cotyledons expand greatly, and change colour from white to green.

Germination is very good and uniform. It attains 70% after 10 days and 95% after 20 days from sowing.

Plant uses

The seed is a source of curcus oil, a powerful purgative. It is also used for illumination, in the manufacture of candles, soap, and lubricants, and in the wool industry. The latex is applied directly to cuts and wounds to stop bleeding, and to sores in the mouth or on the tongue to heal them. Latex and crushed leaves are used for washing clothes. *Jatropha curcas* is planted to mark graves in many parts of Tanzania, and is also used for live fences.

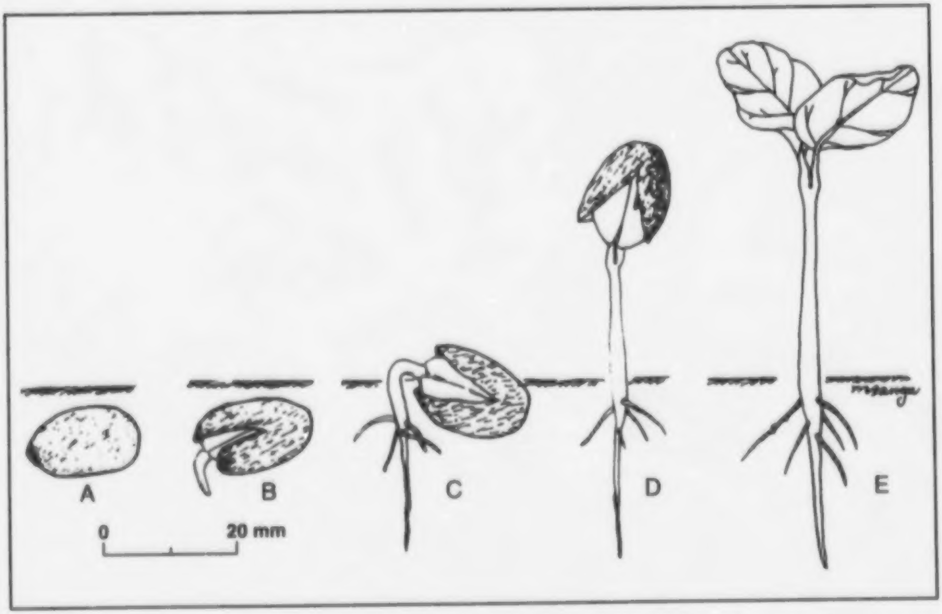

A
B
C
D
E
0
20 mm
msanga

Figure 96. **Stages in seed germination and early development of *Jatropha curcas* seedlings. (A)** At sowing, **(B)** at 5 days, **(C)** at 10 days, **(D)** at 15 days, **(E)** at 20 days after sowing.

Julbernardia globiflora (Benth.) Troupin

LEGUMINOSAE: CAESALPINIOIDEAE

Other names

Mtondo (Kiswahili); muva (Kinyamwezi); mhangala, mtondoro (Kizigua).

Fruit morphology and seed extraction

The fruit is a flat, dark brown pod, 4–9 cm long and 2–3 cm wide. It opens explosively when dry, releasing up to four seeds. About 5 kg of fruits produce 1 kg of seeds.

Seed morphology

The seed is brown, shiny, almost round, flat, about 15 mm wide, with a prominent scar. There are about 1800 seeds per kilogram.

Seed storage

Seeds are orthodox, and properly dried seed can be stored at room temperature for one year without significant loss in viability, if kept dry and insect-free.

Seed presowing treatment

The seed should be soaked in cold water for six hours.

Seed germination

Germination is epigeal (Figure 97), and commences with bursting of the seed coat. The radicle emerges and develops into a taproot. The hypocotyl elongates, without bending, and carries the cotyledons and the seed coat above the germination medium. The first leaves and the young shoot push their way between the cotyledons.

Germination is very good and uniform, attaining 50% after 10 days and 98% after 15 days from sowing.

Plant uses

The tree is suitable for firewood, charcoal, tool handles, beehives and bee forage. The bark provides fibre for making ropes and sacks.

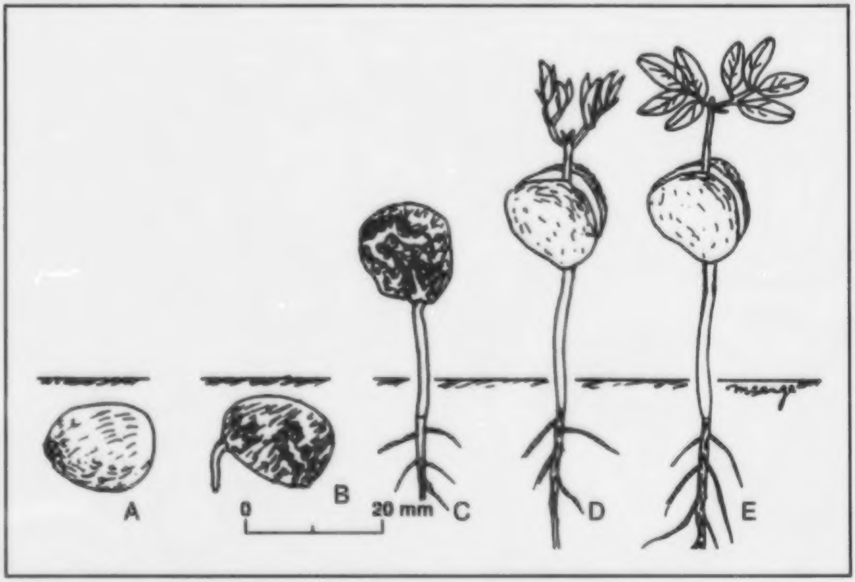

A
B
0
20 mm
C
D
E
msanga

Figure 97. Stages in seed germination and early development of *Julbernardia globiflora* seedlings. (A) At sowing, **(B)** at 4 days, **(C)** at 7 days, **(D)** at 12 days, **(E)** at 16 days after sowing.

Juniperus procera Hochst. ex Endl.

CUPRESSACEAE

Other names

East African juniper, East African pencil cedar; mwangati (Kisambaa); mtarakwa (Kichaga); ol darakwa (Kimasai, Kiarusha); selemuka (Kinyakyusa).

Fruit morphology and seed extraction

The mature fruit is a purple-blue, fleshy, berry-like cone, about 8 mm in diameter, and containing one to four seeds. Fruits are collected from the ground after natural shedding. Fruits should first be soaked in water for six hours, then squeezed by hand to remove the pulp around the seeds. Water, pulp and empty seeds should then be poured off, leaving filled seeds. Seeds should be dried in the sun for one day.

Another method is to dry the fruits in the sun, then pound the dried fruits in a mortar and clean the seeds by winnowing.

Seed morphology

The seed is hard, light brown, three-angled, and about 6 mm long and 4 mm wide. There are about 45 000 seeds per kilogram.

Seed storage

Seeds are orthodox, and should be stored in a cool (2–5°C), dry place. Where such conditions are not available, seeds can be kept at ambient air temperature, out of direct sunshine. Seeds can be stored for one year without significant loss of viability.

Seed presowing treatment

Pretreatment is needed to overcome both embryo and seed coat dormancy. Seed should be soaked in concentrated sulphuric acid for 10 minutes to break seed coat dormancy (*see* chapter on seed presowing treatments). Embryo dormancy can be overcome by a sequence of imbibition and stratification. Seeds are first soaked in water, then moist seed are stratified at ambient temperature for 30 days, followed by cold stratification at 5°C for 30 days (*see* Albrecht, 1993).

Seed germination

Germination is epigeal (Figure 98). The seed absorbs water but does not swell. The seed coat splits slightly and the thin white radicle emerges. The hypocotyl and two cotyledons elongate while carrying the remains of the seed coat. The cotyledons develop and push their way out, and the seed coat falls off.

Germination is fair, but slow and sporadic, even after pretreatment. With untreated seeds, germination reaches 5% after two months and 40% after six months from sowing. With treated seeds, germination may reach 50% after six weeks.

Plant uses

The wood is durable and is used for furniture, fence posts, building poles, pencils, wardrobe-linings, flooring, roofing shingles, telephone and electric power transmission poles, and essential oil. The branches provide excellent firewood. The tree is valuable for erosion control in montane areas, and can be planted on rocky slopes.

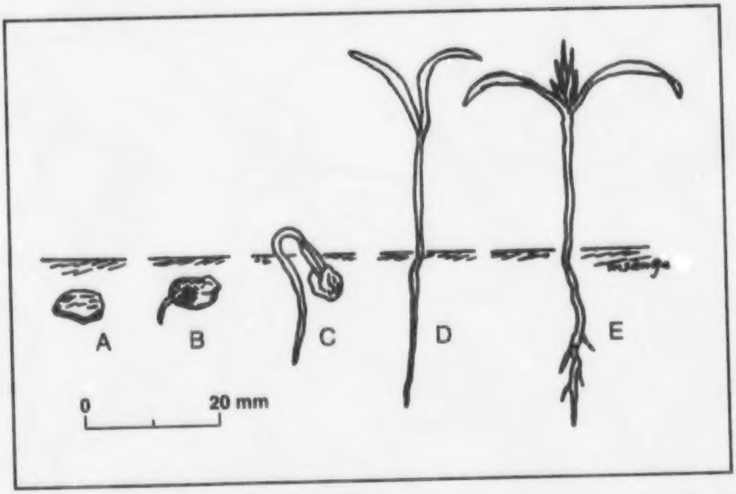


Figure 98. **Stages in the germination of untreated *Juniperus procera* seed and early development of the seedlings. (A)** At sowing, **(B)** at 30 days, **(C)** at 35 days, **(D)** at 45 days, **(E)** at 3 months after sowing.

Khaya anthotheca (Welw.) C. DC.

MELIACEAE

Other names

African mahogany; mkangazi, mtondoo, mtondoro (Kiswahili).

Fruit morphology and seed extraction

The fruit is a woody capsule (Figure 99), almost round, 3–4 cm in diameter, creamy-brown, splitting into four to five valves when dry, and containing up to 40 seeds. Unopened, ripening capsules are collected from the tree, and drying is completed under shade. Partly opened capsules may be dried in the sun. Alternatively, capsules may also be collected on the ground soon after natural shedding and drying completed in the sun. Opened capsules may be shaken in a concrete mixer to release seeds. About 5 kg of fruits produce 1 kg of seeds.

Seed morphology

The seed is chocolate-brown, flat, 1.5 cm broad and 2.5 cm long; a narrow wing extends around the seed. There are about 4000 seeds per kilogram.

Seed storage

Seeds are intermediate between orthodox and recalcitrant, and should be stored in a cool (2–5°C), dry place. Where such conditions are not available, seeds can be kept at ambient temperature, out of direct sunshine. Seeds should be sown within one year after collection.

Seed presowing treatment

No seed pretreatment is required.

Seed germination

Germination is hypogeal (Figure 100). Seven days after sowing, the radicle starts to emerge near the scar, and later develops into a taproot. The cotyledonary stalks elongate while the young epicotyl emerges between them. The cotyledons are left within the seed coat and remain in the soil, attached to the seedling.

Germination is very good but sporadic. It attains 20% after one week and 90% after three weeks from sowing.

Plant uses

The wood is used for panelling, furniture, flooring and boat-building. The bark infusion is bitter, and is drunk to relieve colds.

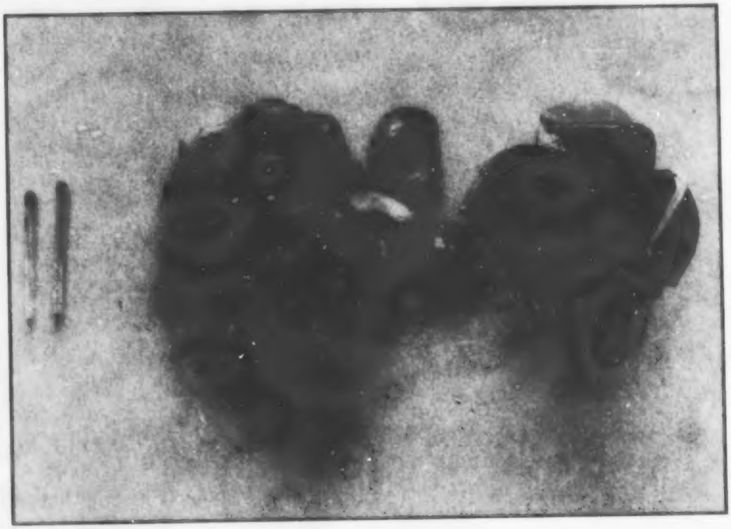


Figure 99. ***Khaya anthotheca*** **fruit and seeds.**

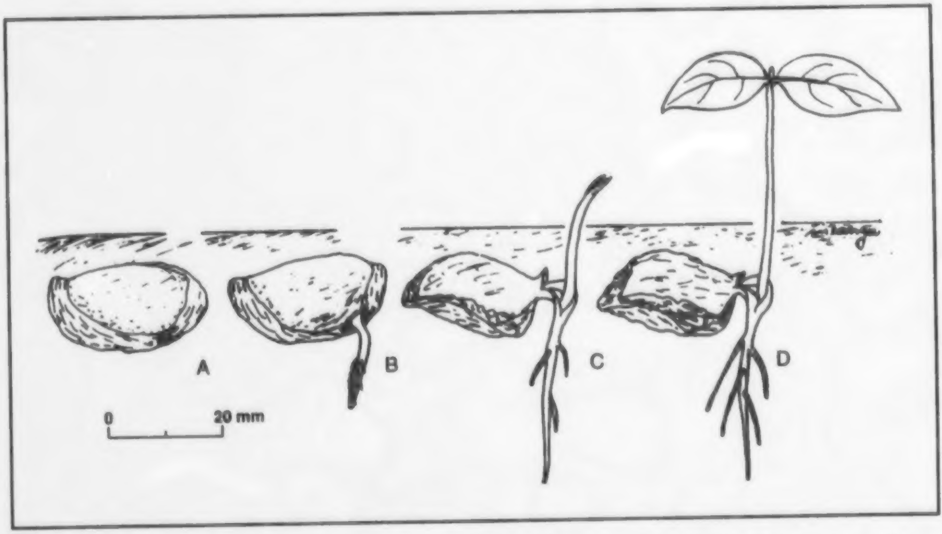


Figure 100. Stages in seed germination and early development of *Khaya anthotheca* seedlings. **(A)** At sowing, **(B)** at 10 days, **(C)** at 18 days, **(D)** at 25 days after sowing.

***Kigelia africana* (Lam.) Benth.**

Syn. *Kigelia aethiopum* (Fenzl) Dandy
***Kigelia aethiopica* Decne.**
***Kigelia pinnata* (Jacq.) DC.**

BIGNONIACEAE

Other names

Sausage tree; mwegea (Kiswahili); mukisha, mratine (Kipare); msanghwa (Kinyamwezi); mzengute (Kihaya).

Fruit morphology and seed extraction

The fruit is a large, sausage-shaped, grey-green, heavy capsule, about 40 cm long and 15 cm wide. The fibrous pulp contains many seeds, which are released only by smashing the fruit, or when the fruit rots on the ground. About 20 kg of fruits produce 1 kg of seeds.

Seed morphology

The seed is flat, pointed at the base, and with a deep longitudinal groove on one of the narrow sides. It has a rough yellowish-brown seed coat. There are about 5000 seeds per kilogram.

Seed storage

The seed is intermediate between orthodox and recalcitrant, and can be stored for two months at room temperature without significant loss of viability.

Seed presowing treatment

The seed does not require pretreatment.

Seed germination

Germination is epigeal (Figure 101). The radicle emerges from the pointed end and develops into a taproot. The seed coat splits longitudinally along the groove, and the two leafy cotyledons unfold and expand greatly. The cotyledonary stalks remain partly buried in the germination medium.

Germination is very good and uniform. It reaches 50% after 15 days and 95% after 20 days from sowing.

Plant uses

The fermented fruit is used by the Wapare people of north-eastern Tanzania as a catalyst in the fermentation of sugar syrup into a potent local brew called "dengelua". The timber is used for dugout canoes, while the flowers are ornamental and provide good bee forage.

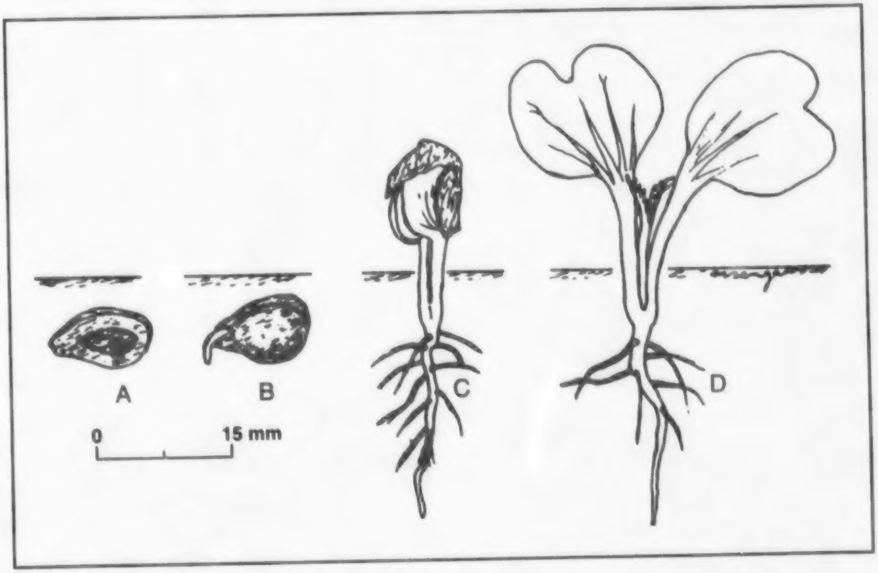


Figure 101. Stages in seed germination and early development of *Kigelia africana* seedlings. (A) At sowing, (B) at 5 days, (C) at 10 days, (D) at 15 days after sowing.

Lannea schweinfurthii (Engl.) Engl.

ANACARDIACEAE

Other names

Mtundu (Kiswahili); msighe (Kipare); mumbu (Kizigua); muhingilo (Kiluguru); muwumbu (Kigogo); msayu (Kisukuma).

Fruit morphology and seed extraction

The fruit is an elongated, rather flat, red-brown, fleshy drupe, about 10 mm long and 7 mm broad. Each fruit contains one seed. The fruit skin and pulp are removed by macerating in water and then squashing by hand. The seeds are cleaned by washing in water; those which float are discarded. Seeds should be dried under shade. About 6 kg of fruits produce 1 kg of seeds.

Seed morphology

The seed is slightly elongated, flattened, almost kidney-shaped, about 7 mm long and 4 mm broad, with a creamy white leathery skin. There are about 40 000 seeds per kilogram.

Seed storage

The seed is perishable and should be sown within two weeks after collection. It is recalcitrant and cannot tolerate desiccation or freezing temperatures.

Seed presowing treatment

The seed does not require pretreatment.

Seed germination

Germination is epigeal (Figure 102). The radicle emerges through the scar and pushes its way downwards. The hypocotyl bends greatly as it elongates, and carries the cotyledons above the germination medium. The seed coat usually remains on the germination medium.

Germination is fair but sporadic. It reaches 10% after two weeks and 30% after four weeks from sowing.

Plant uses

Deep red and brown dyes are obtained from the bark. In hot climates a brown kapok-like "wool" forms a thick layer on the surface of roots. This wool is used to treat livestock wounds and for stuffing pillows. The fruit is eaten in times of emergency, and the bark is used in preparing a medicine for treating general body weakness.

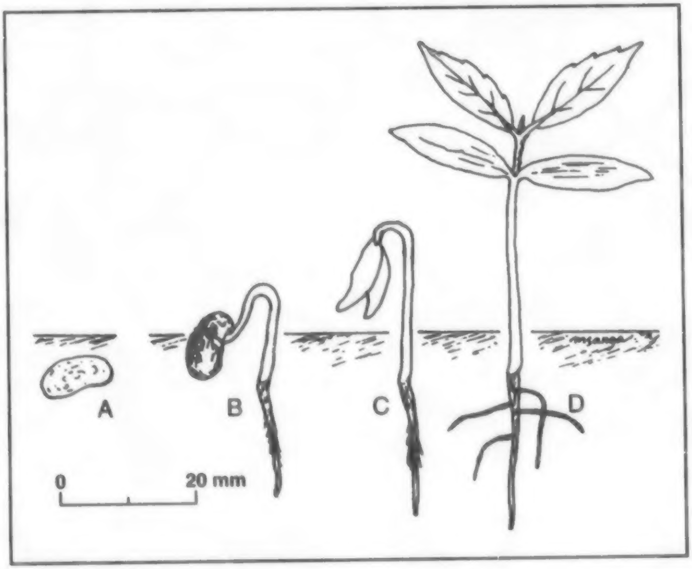


Figure 102. Stages in seed germination and early development of *Lannea schweinfurthii* seedlings. (A) At sowing, **(B)** at 8 days, **(C)** at 10 days, **(D)** at 20 days after sowing.

Leptonychia usambarensis K. Schum.

STERCULIACEAE

Other names

Mchole (Kisambaa).

Fruit morphology and seed extraction

The fruit is a round capsule, about 13 mm in diameter. One side breaks open to release a single seed. The seed is removed from the fruit by shaking. About 18 kg of fruits produce 1 kg of seeds.

Seed morphology

The seed is slightly elongated, narrower on the scar end, about 13 mm long and 7 mm broad, with a thin, greyish seed coat. There are about 15 000 seeds per kilogram.

Seed storage

The seed is intermediate between orthodox and recalcitrant, and can retain viability for two months at room temperature.

Seed presowing treatment

The seed does not require pretreatment.

Seed germination

Germination is epigeal (Figure 103). The radicle emerges through the scar. The hypocotyl elongates and carries the seed coat above the germination medium. The cotyledons are very small and remain in the endosperm. Germination is fair and delayed, reaching 10% after 10 weeks and 40% after 11 weeks after sowing.

Plant uses

The tree provides firewood and poles for hut building.

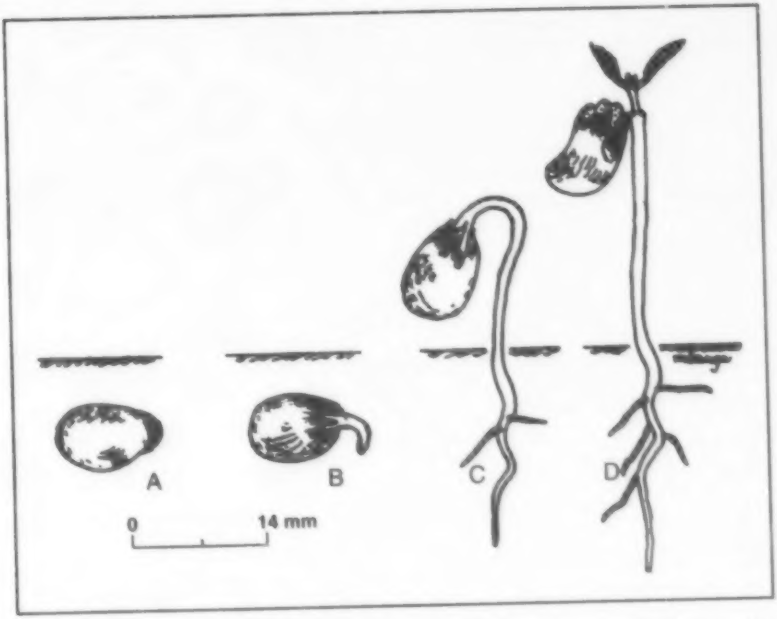


Figure 103. Stages in seed germination and early development of *Leptonychia usambarensis* seedlings. (A) At sowing, **(B)** at 5 weeks, **(C)** at 6 weeks, **(D)** at 10 weeks after sowing.

Lupinus princei Harms
LEGUMINOSAE: PAPILIONOIDEAE

Other names

Iharage la nkoma (Kipare).

Fruit morphology and seed extraction

The fruit is a pod with long, dense hairs, pale green when young, turning brown at maturity, about 6 cm long and 1.5 cm wide. It splits open when ripe to release three or four seeds. Ripening pods are collected from the plants and drying is completed in the sun. After opening, the pods are flailed and shaken to release seed, which can then be cleaned by winnowing. For extraction of bulk quantities of seed, a flailing thresher and an air-screen cleaner can be used (as for *Acacia nilotica).* About 10 kg of pods produce 1 kg of seeds.

Seed morphology

The seed is light brown, about 10 mm long and 5 mm broad, with sides more or less parallel, and four angles, one of which bears a prominent scar. There are about 12 000 seeds per kilogram.

Seed storage

The seed is orthodox and can be stored for two years at room temperature without significant loss of viability, if kept dry and free of insects.

Seed presowing treatment

The seed does not require pretreatment.

Seed germination

Germination is epigeal (Figure 104). The seed coat softens as the seed absorbs water. The cotyledons swell greatly and rupture the seed coat, beginning at the scar. The radicle emerges and develops into a taproot. The hypocotyl elongates vigorously and rises above the germination medium. On exposure to light the cotyledons unfold and release the developing primary leaves. The cotyledonary stalks are folded together to form a tube which envelops the base of the seedling stem.

Germination is good but sporadic. It reaches 50% after three weeks and 75% after six weeks from sowing.

Plant uses

Lupinus princei is an ornamental plant with beautiful, blue flowers. The roots are used in the preparation of traditional medicine. The plant is nitrogen fixing, and suitable for green manuring.

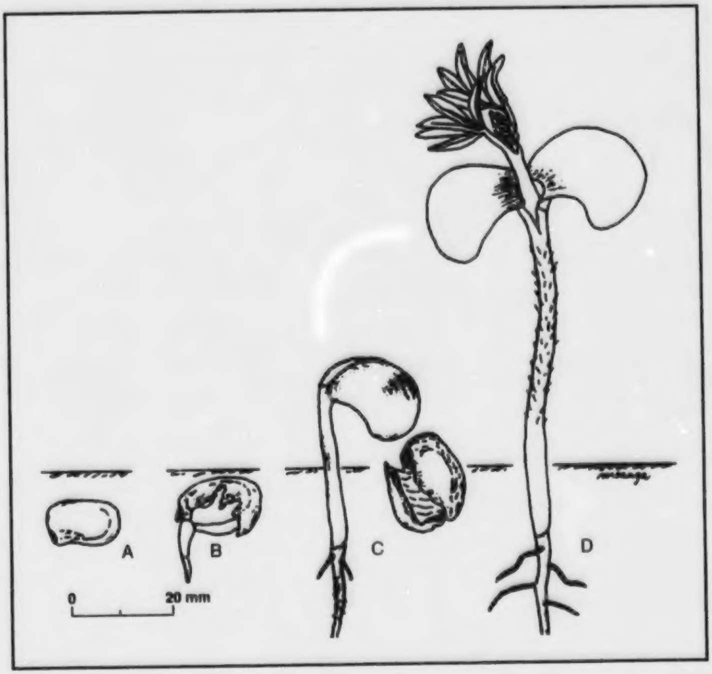


Figure 104. **Stages in the germination of *Lupinus princei* seed. (A) At sowing, (B) at 15 days, (C) at 20 days, (D) at 35 days after sowing.**

Maesopsis eminii Engl.
RHAMNACEAE

Other names

Musizi (Kiswahili); muhumula (Kihaya).

Fruit morphology and seed extraction

The fruit is a pear-shaped drupe, tapering towards the base, about 2.5 cm long, yellowish-green at first and turning black when ripe. Each fruit contains one seed, rarely two. Ripe fruits are collected from the ground soon after natural shedding. For small quantities, the fruit pulp can be removed using a knife or by rubbing the fruits over wire mesh; the seeds are washed in water. For large quantities, the fruit is soaked in water for 24 hours, then mixed with gravel in a proportion by weight of one part gravel and two parts fruit. The mixture is poured into a concrete mixer with large quantities of water and mixed for 30 minutes. Water, pulp and skin are poured off, and gravel is removed by hand. Seeds are spread on a wire mesh tray and dried in the sun, stirring frequently, for several days. About 5 kg of fruits produce 1 kg of seeds.

Seed morphology

The seed is almost pear-shaped, about 2.0 cm long and 1.5 cm broad. There is a thick spongy layer on the outer surface, under which there is a hard, bony covering. Below the bony layer there is a membraneous seed coat. Within these layers is one embryo (rarely two) enclosed by a thin, brown membrane. For practical purposes each fruit with the pulp removed is considered a seed. There are about 550 seeds per kilogram.

Seed storage

Seed is orthodox and can be stored for two years at room temperature without significant loss of viability, if kept dry and free of insects.

Seed presowing treatment

Seed should be soaked in cold water for three days; the water should be changed every 12 hours. For small quantities of seed, manual scarification should precede soaking. Even after scarification, germination is sporadic and prolonged. Other presowing treatments, such as warm stratification, should be tried.

Seed germination

Germination is epigeal (Figure 105). The seed absorbs water and the cotyledons expand, bursting the seed coat from the scar end. The radicle develops, then the hypocotyl elongates, bending, and carries the cotyledons above the germination medium. The seed coat usually splits into two parts and is left on the surface. The cotyledons are thick, more or less rectangular, and tapering towards the base. At first they turn from white to green, but later become black and shrivelled. Germination is good but sporadic. When the seed is pretreated by soaking, germination reaches 30% after seven weeks and 65% after 14 weeks. With such a long germination period, the seeds are usually infected by fungal saprophytes; this further reduces the number of seedlings that can be produced.

Plant uses

Maesopsis eminii is planted as an avenue tree, and grows very quickly in high rainfall areas. In north-eastern Tanzania it is used as a nurse tree in establishing *Cephalosphaera usambarensis*, and is also planted for shade in coffee and banana farms. In Southeast Asia it is a plantation crop. The wood is used in general carpentry, production of veneer, and interior joinery. The tree also provides firewood and fodder for livestock.

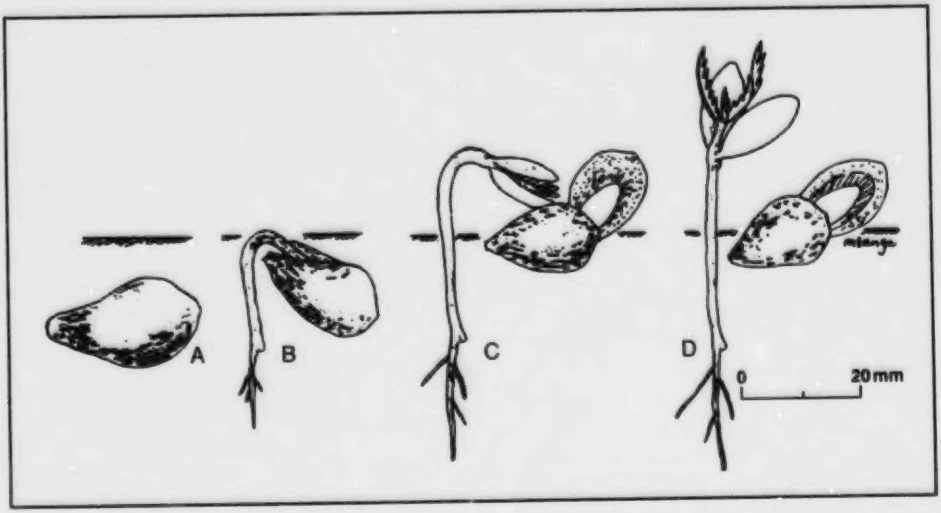


Figure 105. **Stages in the germination of *Maesopsis eminii* seed. (A)** At sowing, **(B)** at 6 weeks, **(C)** at 7 weeks, **(D)** at 8 weeks after sowing.

Manilkara obovata (Sabine & G. Don) J.H. Hemsl.

SAPOTACEAE

Other names

Mnumbulu (Kigogo); mumenge (Kinyamwezi); mukuaya (Kihaya).

Fruit morphology and seed extraction

The fruit is an egg-shaped drupe, 2.5–3 cm long, 1.5–2 cm in diameter, hairy, greenish with milky pulp when young, and yellowish when ripe. Each fruit contains one seed. About 5 kg of fruits produce 1 kg of seeds.

Seed morphology

The seed is hard, shiny, smooth and somewhat flattened, 1.5–2 cm long, and 0.7–1.2 cm wide; it contains an endosperm. There are about 3500 seeds per kilogram.

Seed storage

The seed is orthodox and can be stored for two years at room temperature without significant loss of viability, if kept dry and free of insects.

Seed presowing treatment

The seed does not need any pretreatment.

Seed germination

Germination is epigeal (Figure 106). The seed coat cracks at the scar end, then the radicle protrudes and develops into a taproot. The hypocotyl bends greatly while elongating. Later it straightens, and the seed coat may be either carried above the germination medium on two leafy cotyledons or left buried. The cotyledons expand, separate and change from white to green.

Germination is very good and moderately uniform, attaining 40% after four weeks and 95% after six weeks.

Plant uses

The fruit is edible. The wood is used for fuel, tool handles, bows, and carriage beams. The tree is suitable for shade.

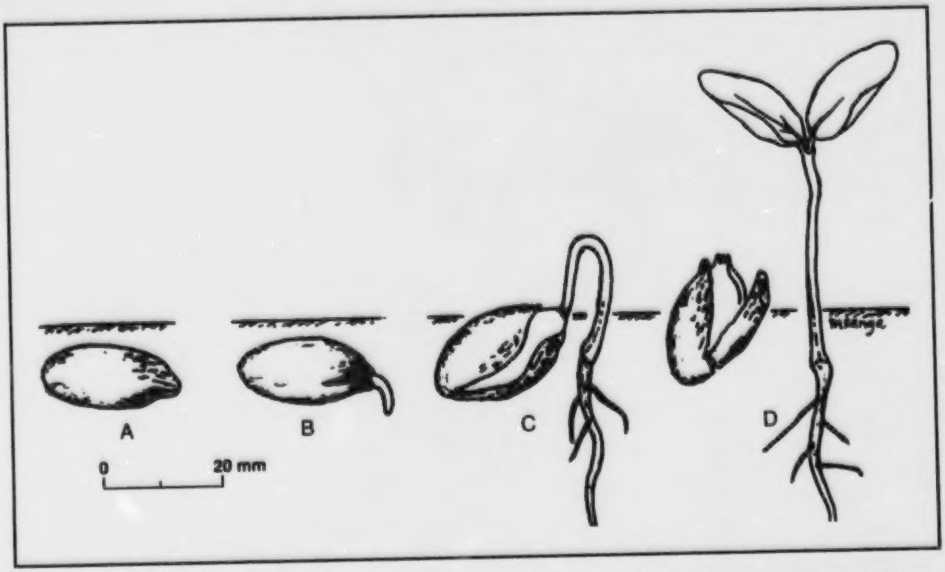


Figure 106. **Stages in seed germination and early development of *Manilkara obovata* seedlings.** **(A)** At sowing, **(B)** at 15 days, **(C)** at 20 days, **(D)** at 30 days after sowing.

Markhamia lutea (Benth.) K. Schum.

BIGNONIACEAE

Other names

Nsambya (Kiswahili); mtanda (Kisambaa); mtalawanda (Kibondei).

Fruit morphology and seed extraction

The fruit is a capsule, up to 80 cm long and 2 cm wide. It bears a prominent ridge along the centre of each side, from base to tip. When dry it splits to release many seeds. The fruit skin is thin and prominently ribbed at the centre. The ripening fruits are collected from trees, and drying is completed in the sun. When the fruits open, they are shaken to release the seeds. About 16 kg of fruits produce 1 kg of seed.

Seed morphology

The seed is flat, with rounded edges, and bears an almost transparent, white, papery wing at each end. The whole seed is about 2.5 cm long and 0.8 cm broad. The seed coat is thin, delicate, and membraneous, resembling a thin layer of pith, so that the embryo is visible from the outside. There are about 75 000 seeds per kilogram.

Seed storage

The seed is orthodox and can be stored for two years at room temperature without significant loss of viability, if kept dry and insect-free.

Seed presowing treatment

The seed does not require pretreatment.

Seed germination

Germination is epigeal (Figure 107). The soft, delicate seed coat and the membraneous wing absorb and retain moisture. The radicle emerges first, then the hypocotyl elongates, raising the large leafy cotyledons, which soon expand. The remains of the seed coat are either left on the ground or drop off with the expansion of the cotyledons.

Germination is fair and uniform. It reaches 35% after 15 days and 50% after 20 days from sowing day.

Plant uses

The tree provides durable transmission poles. The timber is used for furniture, hut-building and agricultural implements. The tree yields good firewood, and is also used as an ornamental; it may be planted near houses because of its beautiful flowers, which are yellow, striped and spotted with red.

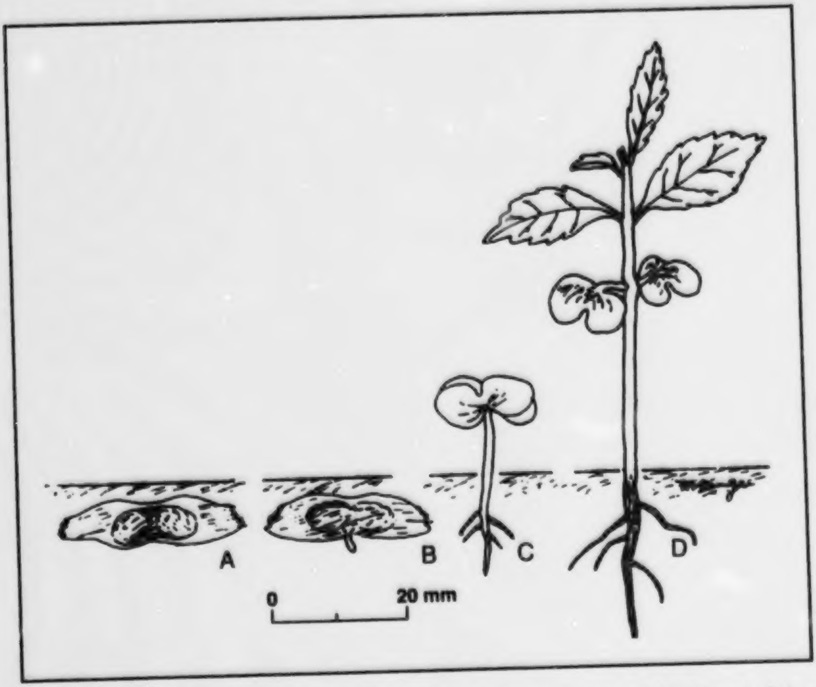


Figure 107. Stages in seed germination and early development of *Markhamia lutea* seedlings. (A) At sowing, (B) at 5 days, (C) at 15 days, (D) at 60 days after sowing.

Milicia excelsa **(Welw.) C.C. Berg**
Syn. *Chlorophora excelsa* (Welw.) Benth.
MORACEAE

Other names

Mvule (Kiswahili); mvure (Kipare); mrie (Kichaga); mzuli (Kihaya); mpugusi (Kihehe); mwale (Kinyakyusa).

Fruit morphology and seed extraction

The compound fruit comprises many small achenes. It is green and mulberry-like, about 6 cm long and 1.2 cm broad, and does not change colour at maturity. Fruits are collected from the ground soon after natural shedding. They should be processed at once to avoid fermentation and heating. The fruits are macerated in water for about six hours, then squashed by hand to squeeze the seeds out of the pulp. The pulp, skin, empty seeds, and water are poured off, leaving clean, filled seeds at the bottom.

For extraction of bulk quantities, the fruits are soaked in water, as for small quantities. They are then mixed with gravel in a proportion by weight of one part gravel and two parts fruits. Together with plenty of water, they are poured into a concrete mixer and stirred for some time. Water, pulp, and empty seeds are then poured off to leave the seeds and gravel at the bottom. The gravel is picked out by hand or separated from the seeds by washing through a sieve with mesh just small enough to retain the gravel. A water-hose is used to facilitate sieving. The seeds are then dried in the sun. About 40 kg of fruits produce 1 kg of clean seeds.

Seed morphology

The seed is small and light-brown, about 1.5 mm long and 1.0 mm broad. It is thinner at the scar end, and has a thin seed coat. There are about 400 000 seeds per kilogram.

Seed storage

Seeds are intermediate between orthodox and recalcitrant, and should be kept in a cool (2–5°C), dry place. Where such conditions are not available, seeds can be kept at ambient air temperature, out of direct sunshine. Seeds should be sown within one year after collection.

Seed presowing treatment

The seed does not need pretreatment.

Seed germination

Germination is epigeal (Figure 108). The seed swells after absorbing moisture, and the radicle protrudes. The seed coat is carried up on the cotyledons, and later falls off as the cotyledons expand.

Germination is good but sporadic. It attains 30% after two weeks and 60% after four weeks from sowing.

Plant uses

The timber is used for exterior and interior joinery, building construction, bridge timbers, docks, carvings, and high grade furniture. Crushed bark, soaked in water, is drunk for heart troubles, lumbago and general fatigue (muku). Liquid obtained from boiled bark is taken as a remedy for elephantiasis of the scrotum. The bark makes excellent charcoal.

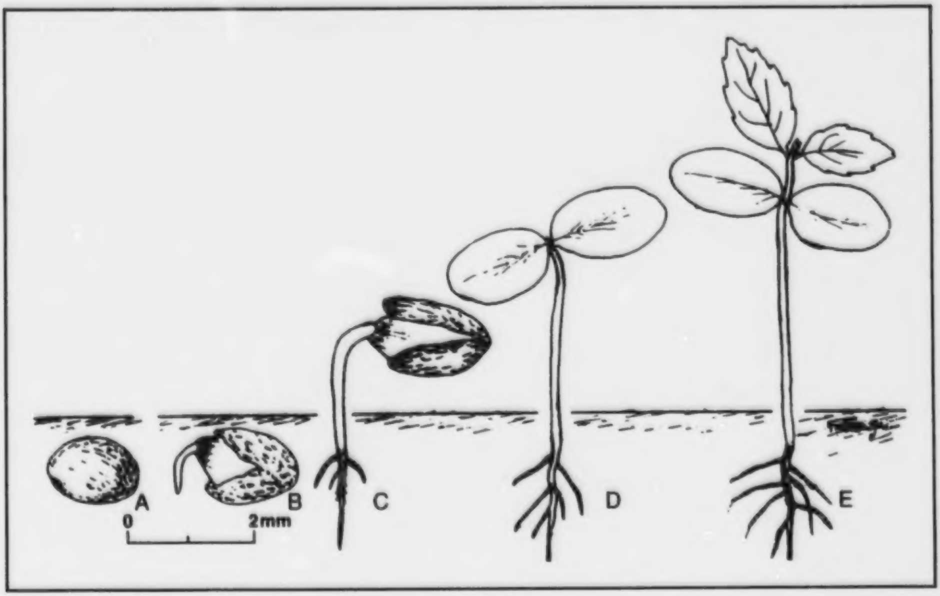


Figure 108. **Stages in the germination of *Milicia excelsa* seed. (A)** At sowing, **(B)** at 10 days, **(C)** at 15 days, **(D)** at 20 days, **(E)** at 30 days after sowing.

Millettia dura Dunn

LEGUMINOSAE: PAPILIONOIDEAE

Other names

Muanvwa (Kipare); omulongo (Kihaya); mhavi (Kiluguru); mhafa (Kisambaa); muhamvi (Kizaramo).

Fruit morphology and seed extraction

The fruit is a hairy pod, 10–16 cm long, 2–3 cm broad, broadest in the upper half, blunt-tipped, and brown when ripe. When dry it splits explosively to scatter one to four seeds. Ripening pods are collected from the tree and drying is completed in the sun. After drying, the pods are opened by hand to extract the seed. Pods may also be threshed in a gunny bag, using a stick. The seed are cleaned by shaking and winnowing. For extraction of large quantities of seeds a flailing thresher is used. About 10 kg of fruits produce 1 kg of seeds.

Seed morphology

The seed has two more or less parallel sides, and rounded ends; it is dark brown, compressed, about 10 mm long and 6 mm broad, with a hard seed coat. There are about 12 000 seeds per kilogram.

Seed storage

The seed is orthodox and can be stored for two years at room temperature without significant loss of viability, if kept dry and free of insects.

Seed presowing treatment

Fresh seeds germinate readily without pretreatment. Stored seeds should be soaked in cold water for 12 hours.

Seed germination

Germination is epigeal (Figure 109). The cotyledons swell and rupture the seed coat at the scar. The radicle emerges and develops into a taproot. The hypocotyl elongates, and carries the seed coat and cotyledons above the germination medium. The seed coat later falls off as the cotyledons expand.

Germination is usually fair but moderately uniform. It reaches 10% after 10 days and 50% after 24 days from sowing.

Plant uses

The tree is used for building poles and for making axe and hoe handles, and the leaves are used as mulch. The tree is also used to shade coffee bushes, and as an ornamental. The wood is used for firewood.

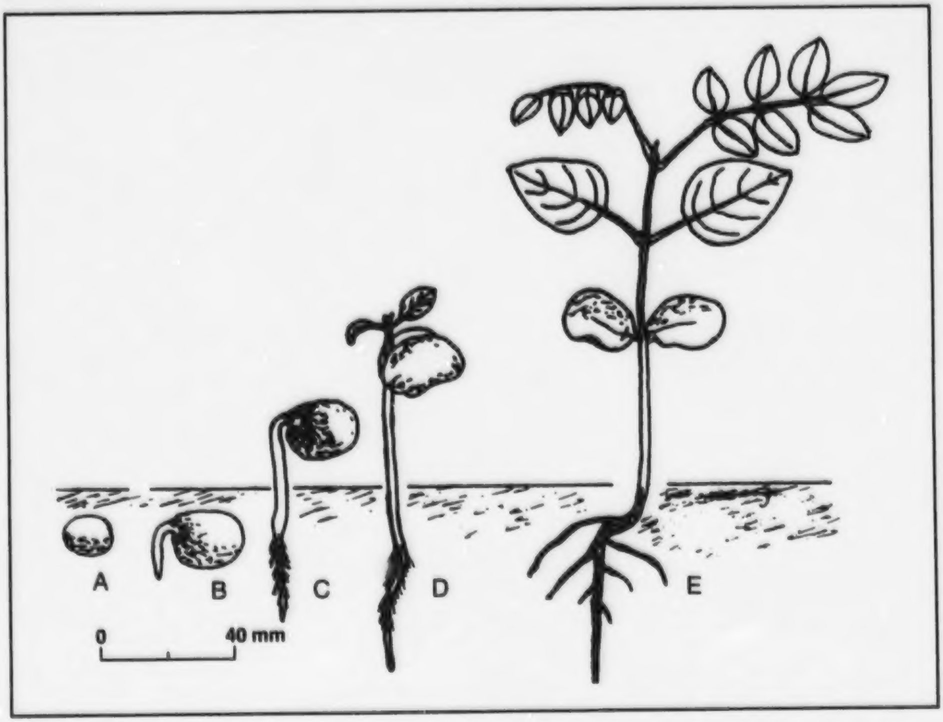


Figure 109. **Stages in seed germination and early development of *Millettia dura* seedlings. (A)** At sowing, **(B)** at 5 days, **(C)** at 7 days, **(D)** at 10 days, **(E)** at 8 weeks after sowing.

Mundulea sericea (Willd.) A. Chev.

LEGUMINOSAE: PAPILIONOIDEAE

Other names

Utupa-wa-pori, mkwaia (Kiswahili).

Fruit morphology and seed extraction

The fruit is a flat pod, finely haired, indehiscent, pale brown to yellow, 5–7 cm long and 0.5 cm broad, containing six to eight seeds. To extract the seeds, dry pods should be threshed in a gunny bag with a stick. Seeds are cleaned by winnowing. About 12 kg of pods produce 1 kg of seeds.

Seed morphology

The seed is almost flat, kidney-shaped, yellowish-brown, and about 7 mm long and 5 mm broad. There are about 80 000 seeds per kilogram.

Seed storage

The seed is orthodox and can be stored for one year at room temperature if kept dry and free of insects.

Seed presowing treatment

Fresh seeds germinate readily without pretreatment. Stored seeds should be soaked in cold water for 12 hours.

Seed germination

Germination is epigeal (Figure 110). The radicle emerges near the scar, then the hypocotyl elongates, bending, and carries the cotyledons above the germination medium. The seed coat usually remains partly enclosing the cotyledons until the cotyledons expand and separate, when it falls off.

Germination is good and moderately uniform. It reaches 10% after 12 days and 75% after 25 days from sowing.

Plant uses

Seeds, leaves and bark are used by fishers to stupefy fish. Bark and leaves are used in making insecticides. The plant can be grown in compounds as a windbreak and as an ornamental with beautiful, purple-pink flowers.

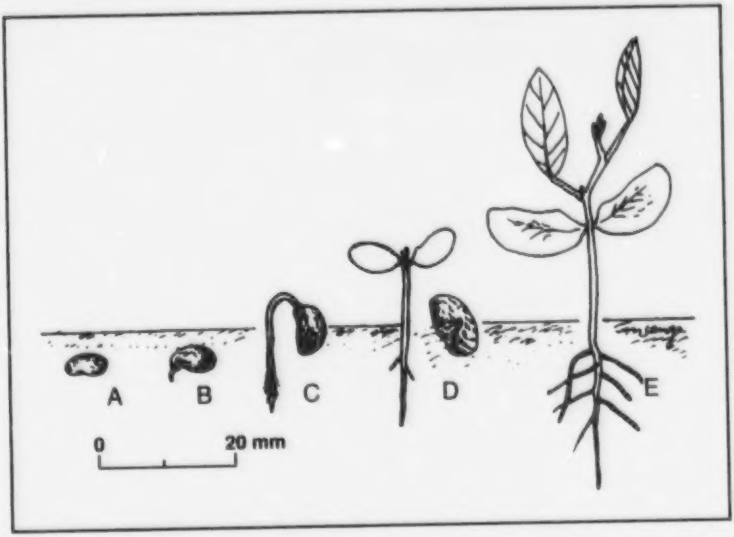


Figure 110. Stages in seed germination and early development of *Mundulea sericea* seedlings. (A) At sowing, **(B)** at 4 days, **(C)** at 10 days, **(D)** at 15 days, **(E)** at 6 weeks after sowing.

Newtonia buchananii (Baker f.) G.C.C. Gilbert & Boutique

Syn. *Piptadenia buchananii* Baker f.

LEGUMINOSAE: MIMOSOIDEAE

Other names

Mkofi, mshashita (Kipare); mnyasa (Kisambaa, Kinguu); mkufi (Kichaga).

Fruit morphology and seed extraction

The fruit is a pod, variable in length, up to 30 cm long and 2 cm broad (Figure 111). Pods are flat, linear, smooth, much veined, and red when mature; they burst along one side when dry. The ripening pods are collected from trees and drying is completed in the sun. When the pods begin to open, the seeds are detached by hand or by shaking in a tray. About 15 kg of fruits produce 1 kg of seed.

Seed morphology

The seed is thin and flat, glossy, dark brown, up to 7 cm long and 1.5 cm wide, with rounded edges and a narrow surrounding wing. There are about 8000 seeds per kilogram.

Seed storage

Seeds are orthodox, and should be kept in a cool (2–5°C), dry place. Where such conditions are not available, seeds can be kept at ambient temperature out of direct sunshine. Seeds should be sown within one year after collection.

Seed presowing treatment

The seed does not require any pretreatment.

Seed germination

Germination is hypogeal (Figure 112). It begins with the emergence of the radicle, which later develops into a taproot. The cotyledonary stalks elongate, and the epicotyl pushes up between them and develops into the plant stem. The cotyledons are left within the seed coat in the germination medium, and remain attached to the seedling.

Germination is good and moderately uniform. It reaches 30% after 20 days and 75% after 30 days from sowing.

Plant uses

Newtonia buchananii provides a utility timber suitable for general joinery and construction work where it will not be exposed to termites or decay agents; it also provides good firewood. The tree is used in agroforestry to provide fodder and shade, especially in coffee and banana farms. It is an attractive ornamental, and is planted near houses to provide shade.

Figure 111. *Newtonia buchananii* pod and seeds.

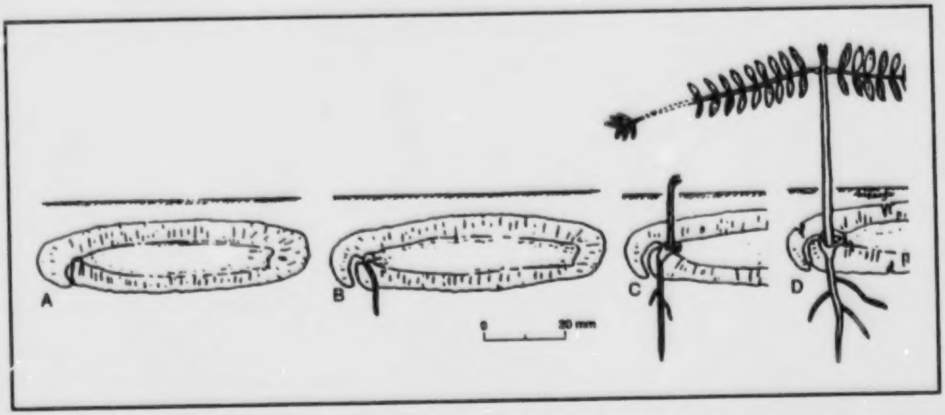


Figure 112. Stages in seed germination and early development of *Newtonia buchananii* seedlings. (A) At sowing, (B) at 10 days, (C) at 20 days, (D) at 60 days after sowing.

Ocotea usambarensis Engl.

LAURACEAE

Other names

East African camphorwood; mase (Kipare); mkulo (Kisambaa); mseri (Kichaga); muheti (Kibena).

Fruit morphology and seed extraction

The fruit is a dark green, round, one-seeded berry, about 8 mm long and 6 mm broad, turning black when ripe. The fruits can be collected from the ground soon after natural shedding. The fruit pulp is removed by macerating in water and then squashing by hand. The seeds are cleaned by washing in water. The pulp, skin, and seeds which float on the surface are discarded. Seeds which sink are retained, then dried in the shade for one day and sown immediately. About 10 kg of fruits produce 1 kg of clean seeds.

Seed morphology

The seed is dark brown, egg-shaped or almost round, about 5 mm long and 4 mm broad. The seed coat is brittle, and has four ridges commencing at the base of the seed and running half way towards the tip. The embryo stalk is buried in a groove between two thick cotyledons. There are about 20 000 seeds per kilogram.

Seed storage

The seed is recalcitrant, and should be packed in small quantities (less than 10 kg) in cotton bags or in gunny bags made of sisal or jute fibre. Alternatively, they can be kept in wire mesh trays under shade. Both methods provide good ventilation.

The seeds cannot tolerate desiccation below 15% moisture content and should be stored at room temperature; they should be sown within six weeks after collection.

Seed presowing treatment

The seed coat is thin, but plays a significant role in seed germination. The seed coat at the scar end must be peeled off before sowing. Soaking fresh seeds in 15% hydrogen peroxide for 25 minutes also increases the germination percentage. To find ways to reduce the long germination period, other pretreatments such as stratification should be investigated.

Seed germination

Germination is hypogeal (Figure 113). The radicle elongates and emerges through the scar, then the shoot breaks through the seed coat on the other side of the seed. The cotyledons are left inside the seed coat, within the germination medium.

Germination is good and somewhat sporadic. It reaches 30% after three weeks and 60% after seven weeks from sowing.

Plant uses

Ocotea usambarensis is a timber tree of economic importance. The wood is one of the best utility hardwoods in Tanzania; it is used mainly for furniture, but also for internal and external joinery, vehicle building, boat ribs, flooring, and coffin boards. The wood obtained from large branches is used for making traditional grain mortars. A bark decoction is used for the relief of stomach ache and gastric conditions, and to treat coughs and malaria.

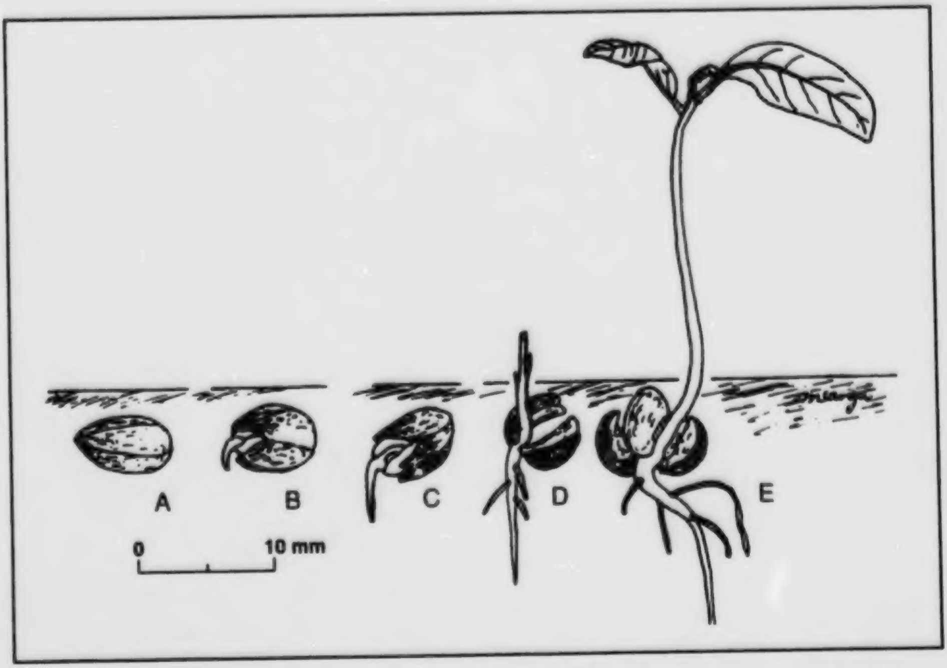


Figure 113. **Stages in seed germination and early development of *Ocotea usambarensis* seedlings.** **(A)** Untreated seed at sowing day, **(B)** at 10 days, **(C)** at 15 days, **(D)** at 20 days, **(E)** at 60 days after sowing.

Opuntia vulgaris J.S. Muell.

CACTACEAE

Other names

Cactus, prickly pear; mkofi (Kisambaa); furahishamkundu (Kiswahili).

Fruit morphology and seed extraction

The berry-like fruit is egg-shaped, succulent, about 5 cm long and 3 cm wide, and yellowish-pink when ripe, with groups of fine spines on the surface. It has many seeds embedded in a juicy, pink-red pulp. To extract seeds the fruit is cut into four parts and squashed by hand to squeeze the seeds from the pulp. After mixing with water, the pulp, fruit skin and empty seeds are poured off, leaving clean seeds at the bottom. About 20 kg of fruits produce 1 kg of seeds.

Seed morphology

The seed is round, flat, hard, light-brown, and about 7 mm across, with a depression at the centre of the flat faces. There are about 40 000 seeds per kilogram.

Seed storage

The seed is orthodox and can be stored for one year at room temperature.

Seed presowing treatment

The seed does not require pretreatment.

Seed germination

Germination is epigeal (Figure 114). The radicle emerges from the scar, and later many adventitious roots develop from it. The hypocotyl bends as it elongates. The cotyledons also elongate and are pulled out from the seed coat, which is usually left in the germination medium. Later a succulent stem, with groups of fine spines, extends between the cotyledons.

Germination is very good and fairly uniform. It reaches 10% after three weeks and 80% after five weeks.

Plant uses

The fruit is edible and is used in making wine in South Africa. This cactus is a native of South America and is naturalized in Tanzania, where it was introduced to control soil erosion in dry and rocky areas.

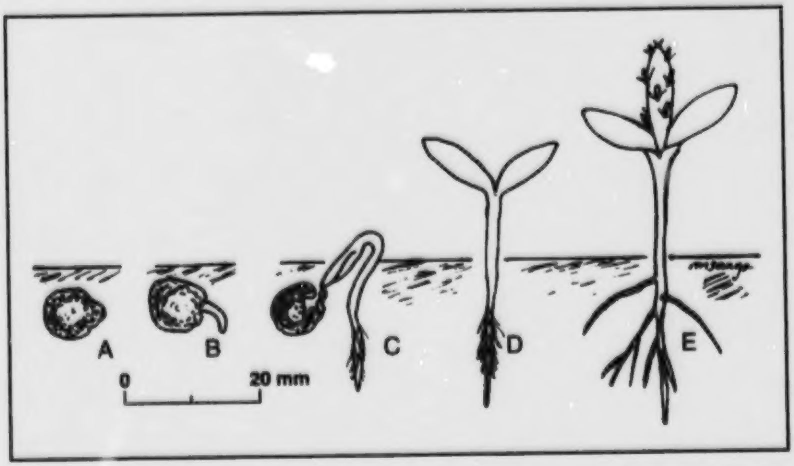


Figure 114. Stages in seed germination and early development of *Opuntia vulgaris* seedlings. (A) At sowing, (B) at 1 week, (C) at 2 weeks, (D) at 3 weeks, (E) at 10 weeks after sowing.

Osyris lanceolata Hochst. & Steud. ex DC.
Syn. *Osyris abyssinica* Hochst. ex A. Rich.
SANTALACEAE

Other names

East African sandalwood; msandali (Kiswahili); kizulu (Kipare); mzuu (Kisambaa).

Fruit morphology and seed extraction

The fruit is a small, spherical drupe, bright red when ripe. The ripe fruits are picked from trees. The pulp is removed by soaking the fruits in water for one day and then squashing by hand. The seeds are then washed in water and dried in the shade for two days. About 8 kg of fruits produce 1 kg of seeds.

Seed morphology

The seed is spherical, about 7 mm in diameter, yellowish brown, with a brittle seed coat. There are about 10 000 seeds per kilogram.

Seed storage

The seed is suspected to be intermediate between orthodox and recalcitrant and can be stored for up to a year at room temperature without significant loss of viability.

Seed presowing treatment

No pretreatment has been tested, but sand paper scarification at the base, or complete removal of the seed coat, may give good results. The seed coat is thin but impermeable to water. It is suspected that an inhibitory compound may be produced during seed processing, and that this delays germination.

Seed germination

Germination is hypogeal (Figure 115). First the seed coat cracks at the scar and the radicle emerges, later developing into a taproot. The cotyledonary stalks elongate, and between them the epicotyl extends and develops into the seedling stem. The cotyledons are left in the seed coat within the germination medium, and remain attached to the seedling for a considerable time.

With untreated seed, germination is fair and moderately uniform. The germination period is about six to eight weeks, during which only about 50% of the seeds can be expected to germinate.

Plant uses

Wood from the stem and root is a source of sandalwood oil, which is used in perfumes, soaps and cosmetics. Prior to 1970, oil produced by Sandalwood Industries at Mombo, Tanzania, was exported to the United Kingdom. Powdered root is boiled in water, and drunk with milk or mixed with meat to treat gonorrhoea, or as a refreshment. The stem and branches are used for firewood. Pounded bark is rubbed on sores of the scalp, while powdered bark of the root is applied to body sores and fresh wounds to promote healing. A liquid obtained from boiled roots of *Osyris lanceolata*, *Clutia abyssinica* and *Solanum incanum* is administered to treat cancer.

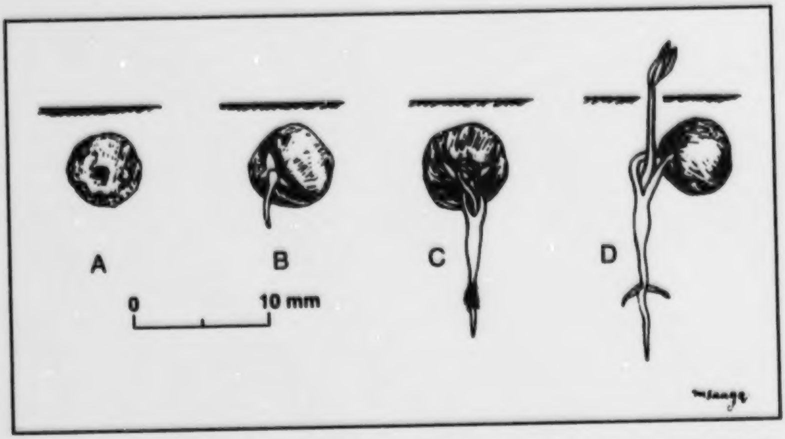


Figure 115. **Stages in the germination of untreated *Osyris lanceolata* seed. (A) At sowing, (B) at 5 weeks, (C) at 6 weeks, (D) at 7 weeks after sowing.**

Oxystigma msoo Harms
LEGUMINOSAE: CAESALPINIOIDEAE

Other names

Msoo (Kichaga).

Fruit morphology and seed extraction

The fruit is a one-seeded pod, and is considered as a seed. Fruits are collected from the ground soon after shedding.

Seed morphology

The seed (strictly speaking, a fruit) is almost flat, egg shaped, about 4 cm long and 3 cm broad (Figure 116). It is thicker at the scar end, and is brown with a leathery skin. There are about 100 seeds per kilogram.

Seed storage

The seed is recalcitrant, and should be packed in small quantities (less than 5 kg) in cotton bags or in gunny bags made of sisal or jute fibres. Alternatively, they can be kept in wire mesh trays under shade. Both methods provide good ventilation.

The seed is susceptible to insect attack. It cannot tolerate desiccation below 20% moisture content, and should be stored at room temperature. Seeds should be sown within six months after collection.

Seed presowing treatment

The seed does not require pretreatment.

Seed germination

Germination is hypogeal (Figure 117). The radicle emerges through the scar and develops into a taproot. The hypocotyl emerges between the cotyledonary stalks; it is stout and covered with scale-like leaves. The cotyledons are left within the seed coat and remain in the germination medium. Germination is fair and uniform, attaining 40% after 15 days and 50% after 25 days from sowing.

Plant uses

The wood is used in making plywood; branches are used for tool handles and fuel.

Figure 116. *Oxystigma msoo* fruit.

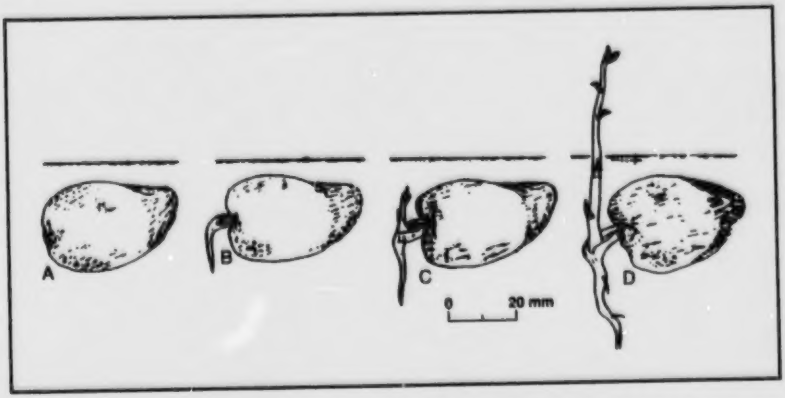


Figure 117. Stages in the germination of *Oxystigma msoo* seed. (A) At sowing, (B) at 10 days, (C) at 20 days, (D) at 50 days after sowing.

Parinari curatellifolia Planch. ex Benth.
CHRYSOBALANACEAE

Other names

Mbula (Kibende, Kinyakyusa, Kinyamwezi, Kizaramo); munanzi (Kihaya); msawola (Kihehe); mbura (Kiswahili).

Fruit morphology and seed extraction

The fruit is a drupe, roughly egg-shaped, up to 4 cm long and 3 cm in diameter, with gray spots over a yellow-red-brown skin. The pulp is fibrous and yellow, and the hard stone contains one seed. When dealing with small quantities, the fruit skin and pulp are removed with a knife and seeds washed in water. For extraction of large quantities, the fruits are soaked in water for 24 hours then threshed using large quantities of water in a flailing thresher machine.

Alternatively, the fruits can be soaked in water for 24 hours and then pounded in a mortar with a wooden pestle. Some coarse sand should be added to facilitate the process. After mixing well with large quantities of water, the broken fruit skins and pulp can be poured, leaving the seeds behind. Extracted seeds should be dried in the sun for at least two days. About 5 kg of fruits produce 1 kg of seeds.

Seed morphology

For practical purposes, each stone with the pulp removed is considered as a seed (Figure 118). It is hard and woody, about 2 cm in diameter, and contains two seeds (kernels). There are about 350 stones per kilogram.

Seed storage

The seed is orthodox. Well dried stones can be stored for up to four years, after which viability gradually decreases.

Seed presowing treatment

Seeds should be soaked in cold water for three days; water should be changed every 12 hours. Because germination is slow and sporadic, even after soaking, other presowing treatments such as warm stratification should be investigated.

Seed germination

Germination is hypogeal (Figure 119). The stone cracks and the thin radicle emerges on the scar end. The shoot then differentiates just above the root. Germination is very poor, delayed and prolonged. It commences only after five weeks and continues for over two years. Germination of 20% has been recorded after three months from sowing.

Plant uses

The fruit pulp is sweet and can be eaten as is, or made into a refreshing drink; it also is used to make a potent alcoholic beverage. The seed, which has a high oil content, is pounded and used for making soup. The tree provides firewood, charcoal, and timber for rafters and poles.

Figure 118. ***Parinari curatellifolia* seeds.**

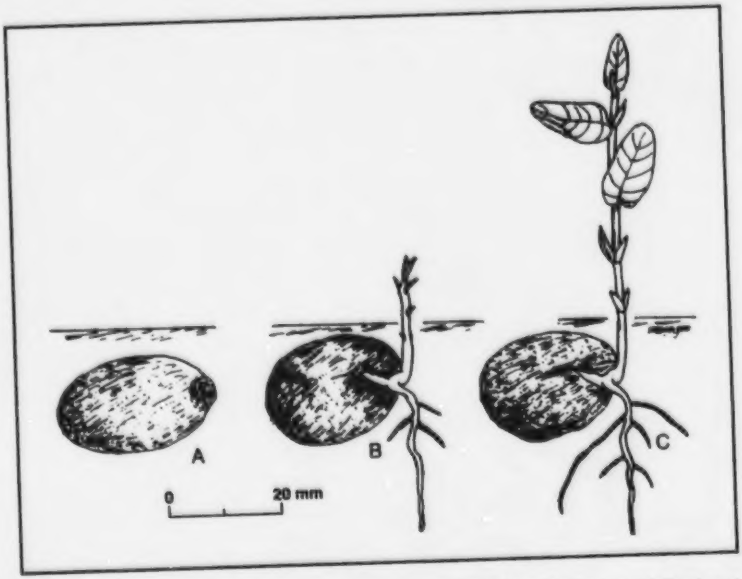


Figure 119. **Stages in seed germination and early development of *Parinari curatellifolia* seedlings.** (A) At sowing, (B) at 5 weeks, (C) at 9 weeks after sowing.

Podocarpus usambarensis Pilg. var. *usambarensis*
PODOCARPACEAE

Other names

Podo; mshunga (Kipare); mse-mwanamke (Kisambaa).

Fruit morphology and seed extraction

The fruit is round, green at first, turning dull purple-green after ripening, and about 2.5 cm in diameter. The fruit pulp is about 3 mm thick and encloses one seed. Ripe fruits are collected from trees or from the ground soon after natural shedding. The outer flesh is removed with a knife. For bulk quantities, the fruits should be after-ripened for four days in a bag made of sisal or jute fibre, after which they should be soaked in water for 24 hours, and then pounded in a mortar. After mixing with water, the broken fruit skin and pulp can be poured off, leaving the seeds. About 4 kg of fruits produce 1 kg of seeds.

Seed morphology

The seed is rounded, about 2 cm in diameter, and covered with a frost-like powder. The seed coat is brown and rough, with a woody shell-like covering about 4 to 6 mm thick. There are about 210 seeds per kilogram.

Seed storage

Seeds are orthodox, and should be kept in a cool (2–5°C), dry place. Where such conditions are not available, seeds can be kept at ambient air temperature, out of direct sunshine. Seeds should be sown within 12 months after collection.

Seed presowing treatment

Complete removal of the woody seed coat, by light hammering or cracking in a table vice, is recommended. Observations show that the intact seed coat physically constrains embryo expansion, resulting in delayed and poor germination of untreated seeds.

Seed germination

Germination is epigeal (Figure 120). After complete removal of the seed coat, the membraneous inner coat (tegmen) splits and the radicle emerges and develops into a taproot. The hypocotyl elongates, carrying the remains of the tegmen, which contains the endosperm and cotyledons. Cotyledons and leaves later develop and push their way out, and the endosperm shrivels.

Germination is good and moderately uniform after complete removal of the seed coat. It reaches 20% after six weeks and 60% after nine weeks from sowing.

Plant uses

The tree provides a high quality utility softwood, used extensively for floor joists and roofing timbers. It is also used for pulp, boxes, furniture, shelving and drawer linings. The tree is planted as an ornamental around homesteads and along roadsides. *Podocarpus* is one of two genera of gymnosperm native to tropical East Africa.

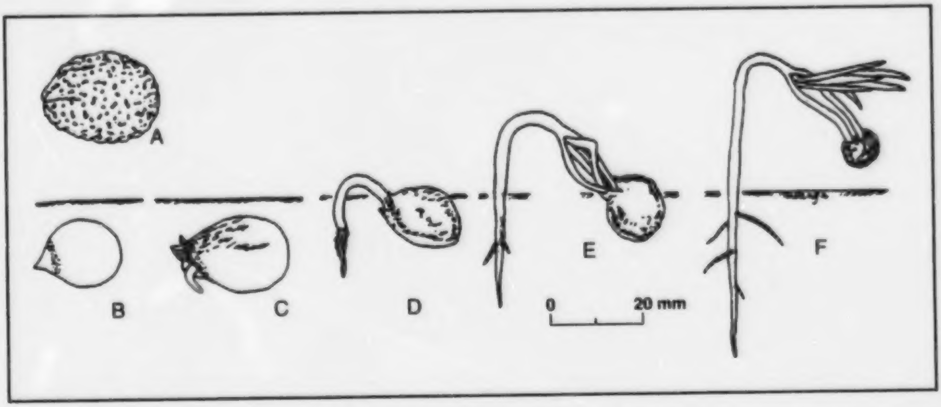


Figure 120. **Stages in the germination of *Podocarpus usambarensis* seed. (A)** Untreated seed, **(B)** seed with its seed coat removed at sowing, **(C)** at 20 days, **(D)** at 30 days, **(E)** at 35 days, **(F)** at 40 days after sowing.

Pterocarpus angolensis DC.
LEGUMINOSAE: PAPILIONOIDEAE

Other names

Bloodwood; mninga (Kiswahili, Kinyamwezi, Kizaramo); mtumbati (Kimwera, Kizaramo); mseseve (Kipare).

Fruit morphology and seed extraction

The fruit is a round, indehiscent pod containing one or two seeds, up to 12 cm in diameter, surrounded by a wavy papery brown wing, and brown at maturity (Figure 121). The central portion is covered with dense bristles.

Dry fruits are spread on the ground, covered with a thin layer of dry grass, and set on fire. The light fire scorches off the wings and bristles, which facilitates handling. Scorched fruits are soaked in cold water for six hours to soften the endocarp. Pods are then opened carefully with secateurs to extract the seeds.

Another method is to use a flailing thresher to remove the bristles, wings and part of the endocarp. Seeds can then be extracted from the endocarp, using secateurs, without presoaking in water. About 50 kg of fruits produce 1 kg of seed.

Seed morphology

The seed is brown, shiny, about 10 mm long and 5 mm wide, with a beak just above the scar. There are about 5700 seeds per kilogram.

Seed storage

Seeds are orthodox, and can be stored for several years at room temperature without significant loss of viability, if kept dry and free of insects.

Seed presowing treatment

Seeds should be soaked in cold water for six hours. Treated seeds should be sown immediately. Untreated seeds will also germinate, but much more slowly.

Seed germination

Germination is epigeal (Figure 122). The seed coat bursts as the radicle emerges; it later develops into a taproot. The epicotyl and the first leaves elongate and push their way up between the cotyledons. The cotyledons remain partly submerged in the germination medium. The seed coat is either left inside the germination medium or carried up by the cotyledons, until they unfold and it falls off.

Germination is good and uniform, reaching 20% after 14 days and 70% after 21 days from sowing.

Plant uses

The wood is one of the best utility hardwoods found in the Miombo ecosystem of Africa. It is used to make high quality furniture, tool handles, and carvings; it is also used for firewood and poles.

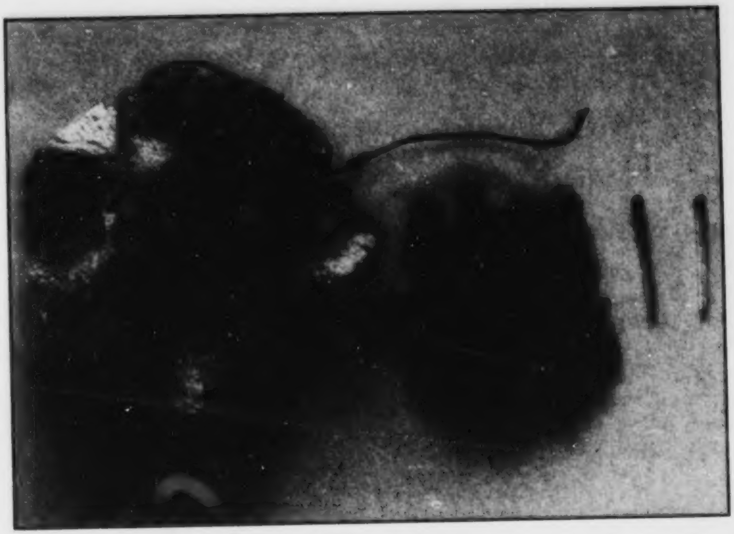


Figure 121. *Pterocarpus angolensis* pod and seeds.

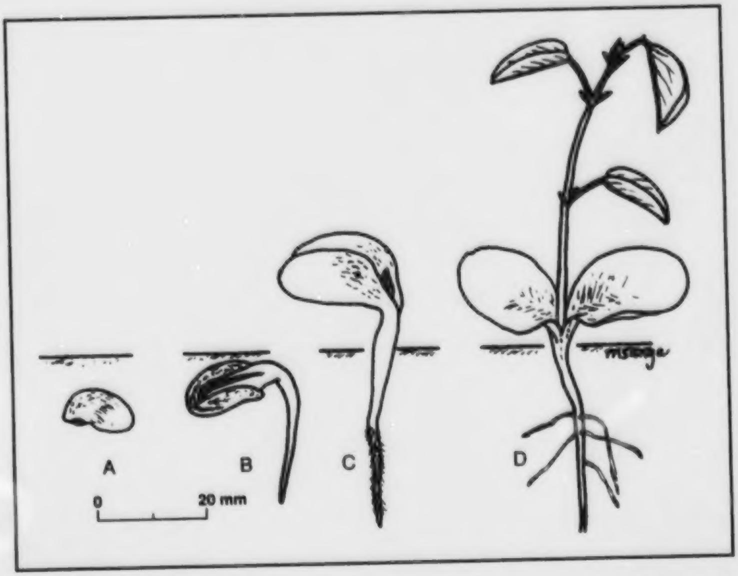


Figure 122. Stages in seed germination and early development of *Pterocarpus angolensis* seedlings. (A) At sowing, (B) at 6 days, (C) at 10 days, (D) at 30 days after sowing.

Pterocarpus tinctorius Welw.

LEGUMINOSAE: PAPILIONOIDEAE

Other names

Muninga maji (Kiswahili); mkiryo (Kipare).

Fruit morphology and seed extraction

The fruit is a flat pod, more or less circular, 10 cm in diameter, and broadly winged. The thickened central part is densely covered with numerous, golden, hair-like bristles. Each fruit contains one or two seeds. To extract seeds, the fruits should be soaked in cold water for six hours, then opened carefully with secateurs or by hand. About 30 kg of fruits produce 1 kg of seed.

Seed morphology

The seed is bean-shaped, red-brown, about 1.4 cm long and 0.8 cm wide. There are about 4700 seeds per kilogram.

Seed storage

The seed is orthodox and can be stored for two years at room temperature without significant loss of viability, if kept dry and free from insects.

Seed presowing treatment

The seed does not require any pretreatment.

Seed germination

Germination is epigeal (Figure 123). The seed absorbs water and swells. The radicle emerges near the scar and develops into a taproot, then the cotyledons unfold and the epicotyl develops. The hypocotyl is very short.

Germination is very good and uniform, reaching 30% after two weeks and 80% after three weeks from sowing.

Plant uses

The wood is used for furniture, poles, door and window frames, and firewood.

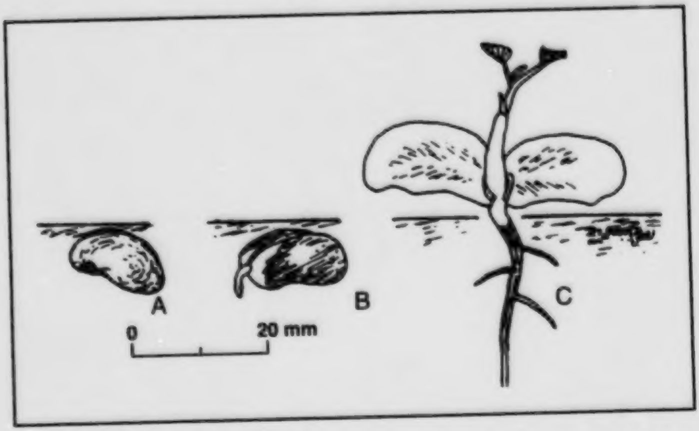


Figure 123. **Stages in seed germination and early development of *Pterocarpus tinctorius* seedlings. (A)** At sowing, **(B)** at 8 days, **(C)** at 14 days after sowing.

Pterygota mildbraedii Engl.
STERCULIACEAE

Other names

Witch tree; mkundi (Kipare); mwifa (Kiswahili); Mguruka (Kisubi).

Fruit morphology and seed extraction

The fruit is an almost round, woody, yellowish-brown, fibrous capsule, about 13 cm in diameter (Figure 124). It splits only along the side to which the seeds are attached. Each fruit contains up to 40 seeds. Fruits are collected from the ground, soon after natural shedding, and drying is completed in the sun. Opened fruits are shaken by hand to release the seeds. About 10 kg of fruits produce 1 kg of seeds.

Seed morphology

The seed has a brown, pithy, surface layer, a brittle brown seed coat, and a long, broad pithy wing on the side opposite the scar. The seed, together with the wing, is about 7 cm long and 2 cm broad. Without the wing and the spongy surface layer, the seed is nearly spherical, and is about 1.5 cm long and 1 cm broad. There are about 1000 seeds per kilogram.

Seed storage

Seeds are intermediate between orthodox and recalcitrant, and should be kept in a cool, dry place. They should be sown within six months after collection.

Seed presowing treatment

The seed does not require any pretreatment.

Seed germination

Germination is epigeal (Figure 125). The seed coat cracks and the radicle protrudes at the scar end. The seed coat is carried up by the hypocotyl on the cotyledons. The leafy cotyledons expand greatly, and change colour from white to green.

Germination is poor and sporadic, reaching only 5% after four weeks and 25% after seven weeks from sowing.

Plant uses

The stem is suitable for plywood. The wood is used for making crates and boxes. The bark is boiled and the liquid drunk to treat malaria.

Figure 124. ***Pterygota mildbraedii* fruit and seeds.**

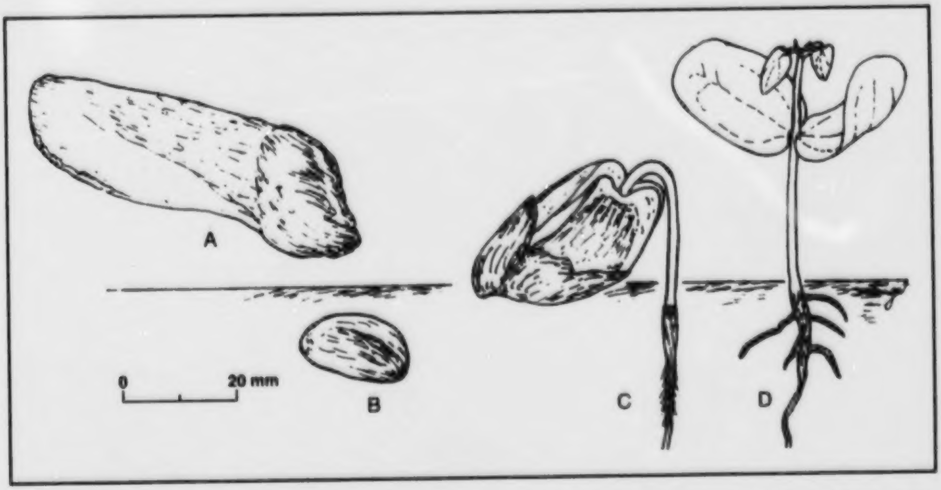


Figure 125. **Stages in seed germination and early development of *Pterygota mildbraedii* seedlings. (A) Seed with wing before sowing, (B) seed without wing at sowing, (C) at 3 weeks, (D) at 4 weeks after sowing.**

Pyrenacantha malvifolia Engl.
ICACINACEAE

Other names

Monkey chair; ing'andiri (Kipare).

Fruit morphology and seed extraction

The fruit is an almost egg-shaped drupe, 1.7 cm long and 1.2 cm wide, wrinkled and light yellow when ripe, containing one seed. The fruit skin is removed by macerating in water and then squashing by hand; the seeds are cleaned by washing in water. About 5 kg of fruits produce 1 kg of seeds.

Seed morphology

The seed is almost egg-shaped but slightly flattened, about 1.4 cm long and 0.8 cm broad, with a soft endosperm and a creamy-white, wrinkled seed coat. There are about 2000 seeds per kilogram.

Seed storage

Seeds are recalcitrant; they should be kept in a cool, dry place and sown within two months after collection.

Seed presowing treatment

The seed does not require pretreatment.

Seed germination

Germination is epigeal (Figure 126). The seed absorbs water and the seed coat cracks at the scar end as the radicle emerges and descends. The hypocotyl swells into a stout tuber-like structure. The cotyledonary stalks elongate greatly and the first leaves protrude between them.

Germination is very good and uniform with fresh seeds, reaching 70% after 15 days and 100% after 20 days from sowing.

Plant uses

The stem forms a very large tuber (1.0–1.5 m in diameter), projecting above the ground and resembling a smooth, grey, rounded, weather-worn stone. Because of this unusual feature, the plant is used as a garden ornamental.

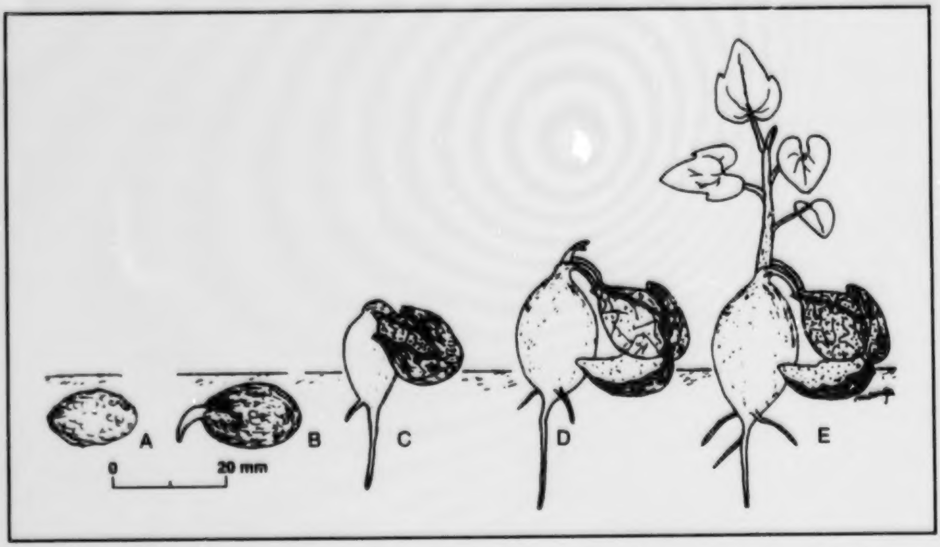


Figure 126. **Stages in seed germination and early development of *Pyrenacantha malvifolia* seedlings. (A)** At sowing, **(B)** at 5 days, **(C)** at 10 days, **(D)** at 15 days, **(E)** at 6 weeks after sowing.

Sclerocarya birrea (A. Rich.) Hochst. subsp. *caffra* (Sond.) Kokwaro

Syn. *Sclerocarya caffra* Sond.

ANACARDIACEAE

Other names

Marula; mng'ong'o (Kiswahili, Kipare, Kinyamwezi, Kinyaturu); mbwejele (Kigogo).

Fruit morphology and seed extraction

The fruit is a fleshy, globular drupe, up to 3.5 cm in diameter, with three indefinite points near the tip (Figure 127). It is yellow when ripe, and has a very juicy pulp. To process small quantities, the skin and pulp are removed with a knife and stones are washed in water. For practical purposes a stone is considered a seed. For extraction of large quantities, fruits are soaked in water for 24 hours, then mixed with gravel in a proportion by weight of one part gravel to two parts fruits. Together with a large volume of water, the mixture is poured into a concrete mixer and stirred for some time. Water, pulp and skin are poured off, leaving the seeds and gravel; the gravel is picked out by hand. Another method is to soak the fruits in water for 24 hours and then pound them in a mortar with a wooden pestle, adding some coarse sand to facilitate the process. The seeds, skin and pulp are mixed with large quantities of water in a bucket and stirred well. The skin, pulp and water are then poured off. After extraction, stones should be dried in the sun for at least two days. About 5 kg of fruits produce 1 kg of stones.

Seed morphology

The seed is a hard, woody stone, about 2 to 2.5 cm in diameter, with three (sometimes two) blunt angles just below the tip. Near each angle point there is a faint line, marking a small rounded "window" which is positioned over the radicle end of one of the two or three kernels. There are about 500 stones per kilogram.

Seed storage

Seed is orthodox. Well dried stones with moisture content of less than 10% can be stored for up to four years, after which viability starts to drop gradually. During transportation, stones should be packed in cotton bags, plastic drums or cardboard boxes.

Seed presowing treatment

The windows should be removed with a small chisel (Figure 127). Complete removal of the kernels is not recommended because of their fragility. The seed coat is very thin and does not delay germination.

Seed germination

Germination is epigeal, commencing with the emergence of the thick, whitish radicle (Figure 128). The hypocotyl elongates, bending, and pulls the cotyledons out from the endocarp, above the germination medium. The cotyledons change from white to green, later becoming brown and shrivelled. With treated stones, germination is very good and uniform, reaching 70% after one week and 85% after two weeks from sowing. With untreated stones germination is sporadic, lasting two to nine months, but occurring mainly between the third and fifth month; germination may reach 50%.

Plant uses

The fruit is edible and is also used to make a local brew and marula wine. The seed is eaten. The wood is used for making traditional stools, carvings, grain mortars, and beehives. The tree provides firewood, timber and fodder.

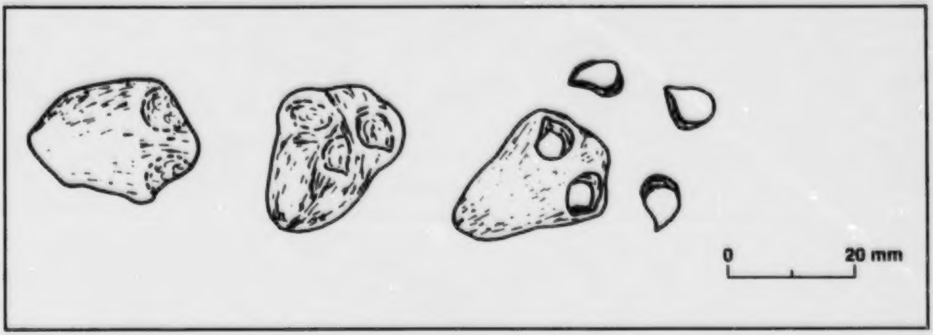


Figure 127. Stones of *Sclerocarya birrea*: two with "windows" intact, and one with windows removed.

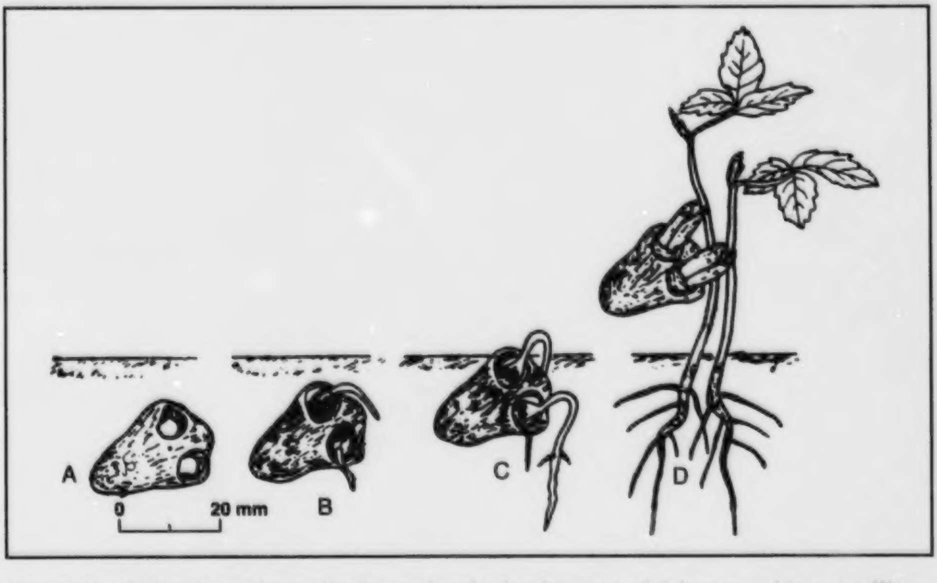


Figure 128. Stages in seed germination and early development of *Sclerocarya birrea* seedlings. **(A)** At sowing, **(B)** at 4 days, **(C)** at 6 days, **(D)** at 2 weeks after sowing.

Senna didymobotrya (Fresen.) Irwin & Barneby

Syn. *Cassia didymobotrya* Fresen.

LEGUMINOSAE: CAESALPINIOIDEAE

Other names

Popcorn bush; isenu (Kipare).

Fruit morphology and seed extraction

The fruit is a flat, yellow-brown pod, straight with transverse indentations, about 7 cm long and 1 cm broad, containing about 20 seeds. Dry pods are threshed in a gunny bag with a stick, or by means of a flailing thresher. About 10 kg of fruits produce 1 kg of seeds.

Seed morphology

The seed is flat, straw-coloured, and compressed, with a hard coat. It is pointed at the scar, or funicle, end, and terminates abruptly at the other end. The flat faces are marked by a line parallel to the outline of the seed. There are about 28 000 seeds per kg.

Seed storage

The seed is orthodox and can be stored for up to three years at room temperature without significant loss of viability, if kept dry and free of insects.

Seed presowing treatment

Freshly harvested seeds do not require any pretreatment. Stored seeds should be treated using a hot wire (*see* section on seed presowing treatments). Bulk quantities should be treated by the hot water method.

Seed germination

Germination is epigeal (Figure 129). The cotyledons swell and rupture the seed coat. The radicle emerges near the funicle scar and descends. The hypocotyl elongates and rises, with the seed coat and cotyledons, above the germination medium. Later the cotyledons expand and separate, and the seed coat falls off.

Germination is very good after pretreatment, reaching 40% after two weeks and 80% after three weeks from sowing.

Plant uses

Popcorn bush is an ornamental plant with beautiful yellow flowers. The stem and branches are used for firewood. The liquid obtained from boiling the leaves is a very powerful purgative.

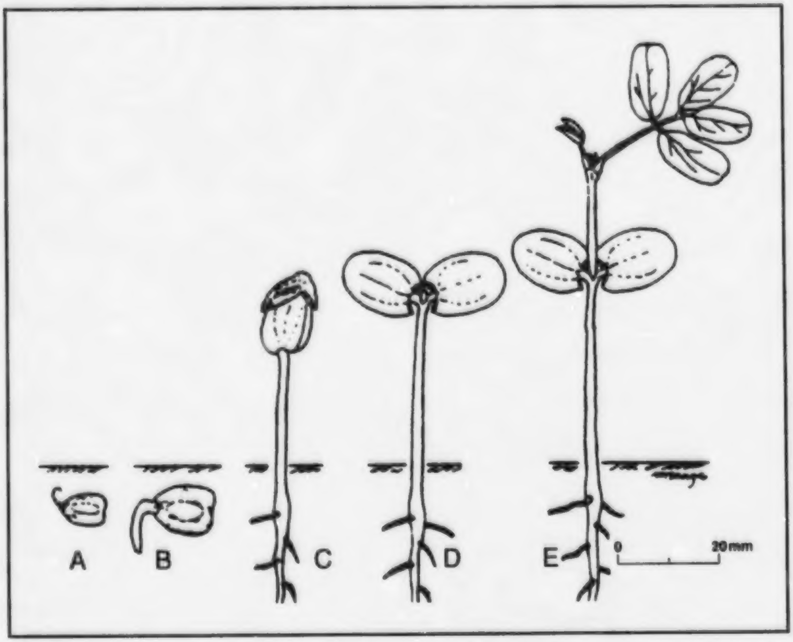


Figure 129. **Stages in seed germination and early development of *Senna didymobotrya* seedlings. (A)** At sowing, **(B)** at 5 days, **(C)** at 10 days, **(D)** at 15 days, **(E)** at 5 weeks after sowing.

Sorindeia madagascariensis Thouars DC.

ANACARDIACEAE

Other names

Mkunguma (Kiswahili, Kipare); mgoda (Kichaga); mpiripiri (Kiswahili); mkwingwina (Kizigua, Kibondei); mpilipili (Kihehe, Kizaramo).

Fruit morphology and seed extraction

The fruit is a drupe, yellow when ripe, up to 2.5 cm long and 1.5 cm in diameter. Ripe fruits are macerated in water for 12 hours then squashed by hand to remove the skin and pulp around the seeds. The pulp and skin are floated in water and poured off, leaving clean seeds at the bottom. About 5 kg of fruits produce 1 kg of seeds.

Seed morphology

The seed is elongated, about 2 cm long and 1 cm broad, and covered with a leathery seed coat. The seed coat has thin, tough, bristly fibres. There are about 2000 seeds per kilogram.

Seed storage

The seed is recalcitrant and should be packed in small quantities (less than 5 kg) in cotton bags or in gunny bags made of sisal or jute fibre. Alternatively, they can be kept in wire mesh trays under shade. Both methods provide adequate ventilation.

The seeds can not tolerate desiccation below 20% moisture content, and should be stored at room temperature. Seeds should be sown within four weeks after collection.

Seed presowing treatment

The seed does not require pretreatment.

Seed germination

Germination is hypogeal (Figure 130). The radicle emerges near the scar of the seed and develops into a taproot. The cotyledonary stalks elongate while the young shoot emerges, bending, between the two stalks. The cotyledons are left within the seed coat, in the soil, and remain attached to the seedling.

Germination is very good with fresh seeds, attaining 20% after two weeks and 80% after three weeks.

Plant uses

Fruits are edible and are used in making a local brew. The wood is heavy and hard, and is good for furniture and general construction.

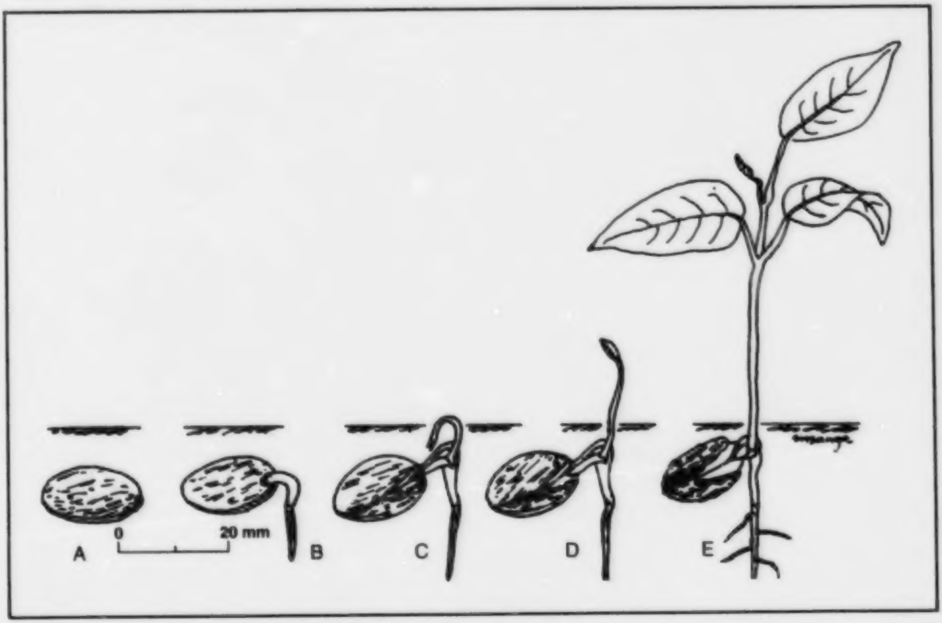


Figure 130. Stages in seed germination and early development of *Sorindeia madagascariensis* seedlings. (A) At sowing, (B) at 7 days, (C) at 10 days, (D) at 12 days, (E) at 6 weeks after sowing.

Spathodea campanulata P. Beauv.

BIGNONIACEAE

Other names

Flame of the forest; kifabakazi (Kiswahili).

Fruit morphology and seed extraction

The fruit is a woody capsule, 25 cm long, which splits to release many seeds. Capsules are held up above the leaves at the top of the tree. Ripening capsules are collected from the trees, and drying is completed in the sun. Opened capsules are shaken to release seeds. About 15 kg of capsules produce 1 kg of seed.

Seed morphology

The seeds are flat, and almost surrounded by a thin, transparent, white, membraneous wing, which encloses a light grey, flat embryo, visible from the outside. The diameter of the seed, including the wing, is about 1.2 cm. Seeds are very light, and are easily blown about. There are about 200 000 seeds per kilogram.

Seed storage

The seed is orthodox and can be stored for up to a year.

Seed presowing treatment

The seed does not require any pretreatment.

Seed germination

Germination is epigeal (Figure 131). The radicle emerges from the hilum side of the seed. The hypocotyl bends slightly, soon straightening as it extends. The membraneous wing gradually rots or washes off. The seed coat may remain in, or on, the germination medium, or may be carried up by the stem, dropping off later as the cotyledons expand.

Germination is fair but fairly uniform. It reaches 5% after 15 days and 40% after 25 days from sowing.

Plant uses

The tree has large, beautiful, red flowers, and is planted as an ornamental and avenue tree. It is also planted for shade in coffee and banana farms. The branches are used for firewood.

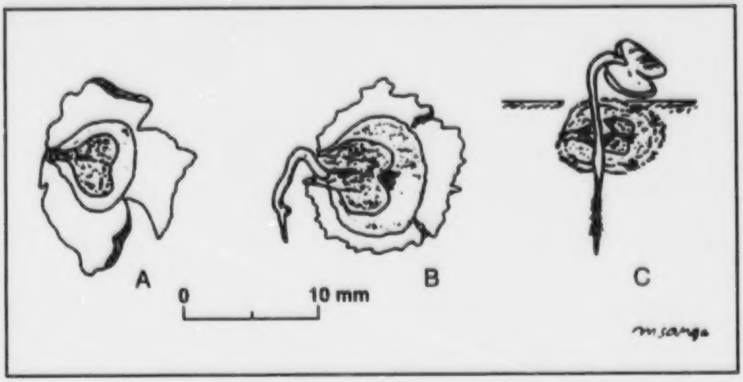

A
0
10 mm
B
C
m.sanga

Figure 131. Stages in seed germination and early development of *Spathodea campanulata* seedlings. (A) At sowing, **(B)** at 15 days, **(C)** at 25 days after sowing.

Sterculia africana (Lour.) Fiori

STERCULIACEAE

Other names

African star chestnut, tick tree; mhozya (Kinyamwezi); mluze (Kigogo).

Fruit morphology and seed extraction

The fruit is a woody capsule with up to five woody, beaked, separate, boat-shaped sections, up to 15 cm long, with short yellow hairs. One side of each section breaks open to release three to ten seeds, which hang like ticks around the open edge. Seeds are removed from the fruits by shaking. About 16 kg of fruits produce 1 kg of seeds.

Seed morphology

The seed is slightly elongated with a caruncle at the base, about 1.0 cm long and 1.5 cm broad, blue-grey, with a thin and peeling seed coat. The seed looks like a tick, hence the English name of tick tree. There are about 16 000 seeds per kilogram.

Seed storage

The seed is apparently intermediate between orthodox and recalcitrant. Seeds can be stored for up to one year at room temperature.

Seed presowing treatment

The seed does not need pretreatment.

Seed germination

Germination is epigeal (Figure 132). The seed absorbs water, and the seed coat cracks at the scar end as the radicle emerges and descends. The hypocotyl grows into a stout, tuber-like structure. The cotyledonary stalks elongate greatly, and the young stem and first leaves emerge between them.

Germination is poor but uniform. It reaches 10% after eight days and 40% after 15 days from sowing.

Plant uses

The timber is used for furniture, and the bark for ropes and mats.

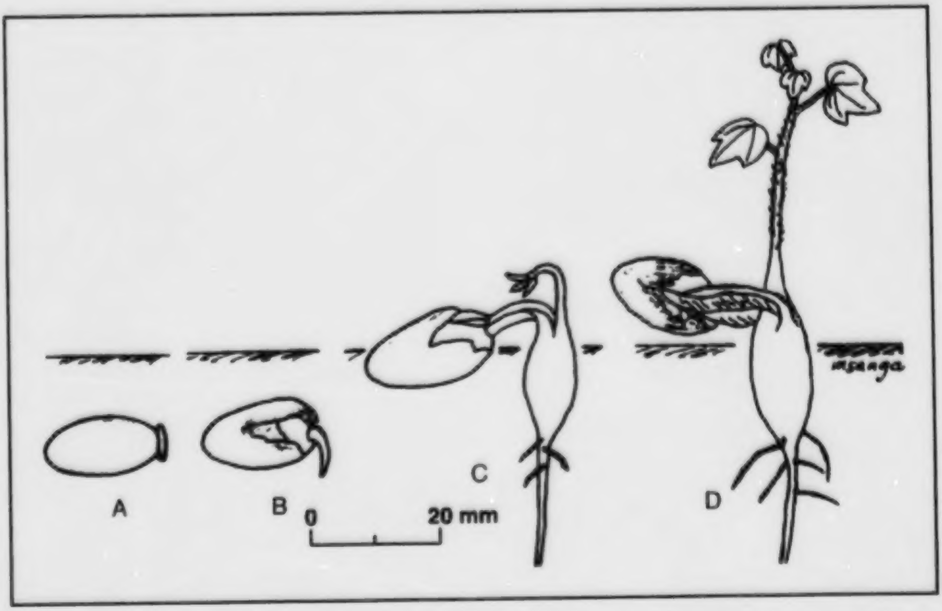

A
B
C
D
0
20 mm
msanga

Figure 132. **Stages in seed germination and early development of *Sterculia africana* seedlings. (A)** At sowing, **(B)** at 5 days, **(C)** at 8 days, **(D)** at 14 days after sowing.

Sterculia appendiculata K. Schum.

STERCULIACEAE

Other names

Tall sterculia; mfune (Kipare, Kiswahili, Kizigua, Kinguu); mgude (Kiluguru, Kinguu, Kizigua); mbalamwezi (Kiswahili).

Fruit morphology and seed extraction

The fruit is a woody capsule made up of two or three separate sections, each about 9 cm long, covered with soft brown hairs. At maturity each section opens to reveal about 12 seeds, which line the edge. Seeds are removed from the fruit by hand or shaking. About 10 kg of fruits produce 1 kg of seeds.

Seed morphology

The seed is about 2 cm long and 1 cm broad, brown with a soft yellow aril almost concealing the seed. There are about 13 000 seeds per kilogram.

Seed storage

The seed can retain viability for up to one year at room temperature.

Seed presowing treatment

The seed does not need any pretreatment.

Seed germination

Germination is epigeal (Figure 133). The seed coat cracks, starting at the scar point, and the radicle protrudes and develops into a vigorous tap root. The shoot elongates, bending greatly, and carries the cotyledons above the germination medium.

Germination is very good and uniform, reaching 40% after two weeks and 80% after three weeks from sowing.

Plant uses

The wood is suitable for making plywood, and the seeds are roasted and eaten. The tree is beautiful and is used for amenity plantings.

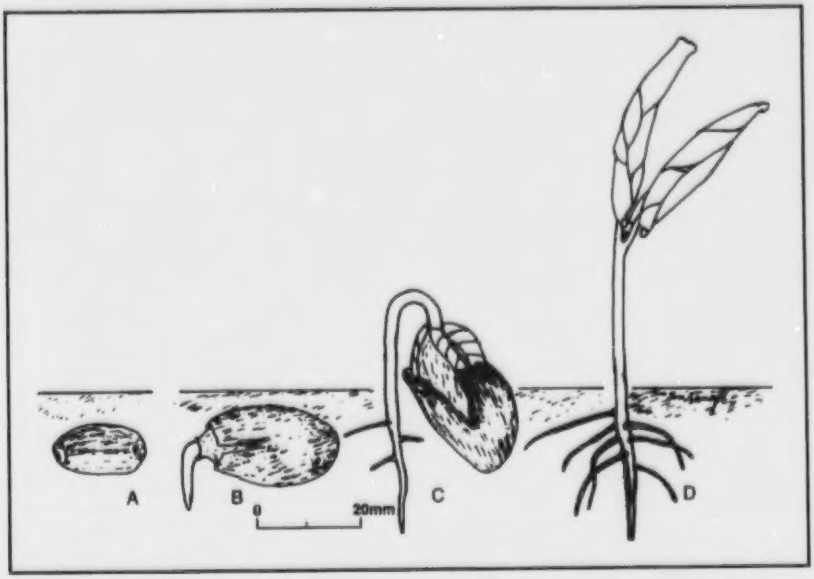


Figure 133. **Stages in seed germination and early development of *Sterculia appendiculata* seedlings. (A)** At sowing, **(B)** at 10 days, **(C)** at 15 days, **(D)** at 20 days from sowing.

Sterculia quinqueloba (Garcke) K. Schum.

STERCULIACEAE

Other names

Large-leaved sterculia; mkweranyani (Kiswahili); mkwelandege (Kisukuma, Kihehe, Kisangu); mkungulanga, mguwa (Kinyamwezi).

Fruit morphology and seed extraction

The fruit is a woody capsule comprising five separate sections, each one up to 6 cm long and 3 cm broad, covered with short hairs. At maturity each section splits along one side to reveal two or three seeds attached to the edge of the opening, among long hairs. Seeds are removed from the fruit by shaking. About 18 kg of fruits produce 1 kg of seeds.

Seed morphology

The seed is round, about 7 mm across, and black, with an inconspicuous caruncle at the base. There are about 25 000 seeds per kilogram.

Seed storage

The seed is recalcitrant and can retain viability for up to two months at room temperature.

Seed presowing treatment

The seed does not need any pretreatment.

Seed germination

Germination is intermediate between hypogeal and epigeal (Figure 134). The seed absorbs water and enlarges greatly. The radicle emerges and descends. The hypocotyl grows into a stout, tuber-like structure. The cotyledonary stalks elongate, and the young stem and first leaves emerge between them.

Germination is fair but moderately uniform. It reaches 13% after two weeks and 43% after three weeks from sowing.

Plant uses

The wood is used for general construction and furniture-making. The bark provides fibre for ropes and mats. The tree is also planted as an ornamental.

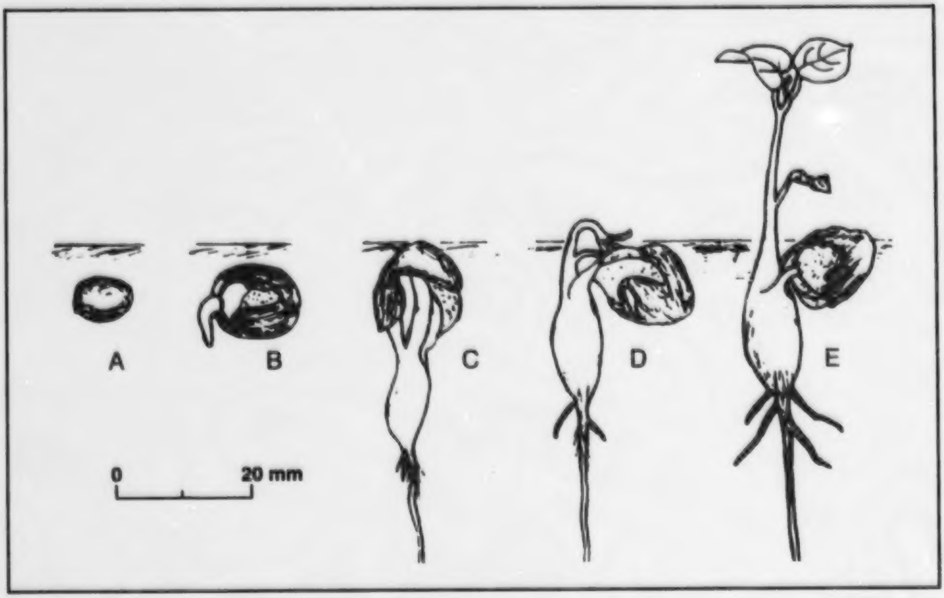


Figure 134. Stages in seed germination and early development of *Sterculia quinqueloba* seedlings. **(A)** At sowing, **(B)** at 5 days, **(C)** at 7 days, **(D)** at 10 days, **(E)** at 14 days after sowing.

Strychnos cocculoides Baker
LOGANIACEAE

Other names

Monkey orange; mtonga, mpera mwitu (Kiswahili); mnywewe (Kihehe); mtonga, mumilwa (Kinyamwezi).

Fruit morphology and seed extraction

The fruit is a large berry resembling an orange in shape and size, hence the English name. It is green at first, turning brown when mature, and sometimes spotted. The skin is very hard and shell-like. The fruit contains 25 to 30 seeds embedded in pulp. To extract seeds, the fruit is first cracked with a knife handle or a piece of wood, then the pulp is scooped out by hand and the seeds squeezed out. The pulp and empty seeds are floated in water and discarded. Filled seeds sink to the bottom, and are dried under shade. About 5 kg of fruits produce 1 kg of seeds.

Seed morphology

The seed is flat, round, about 2 cm in diameter, and creamy-white. There are about 1800 seeds per kilogram.

Seed storage

Seed are intermediate between orthodox and recalcitrant, and can remain viable for six months at room temperature.

Seed presowing treatment

The seed must be washed clean of pulp before it will germinate.

Seed germination

Germination is epigeal (Figure 135). A white radicle protrudes at the scar end and develops into a vigorous taproot. The seed coat is carried up by the hypocotyl on the cotyledons. The leafy cotyledons change colour from white to green.

Germination is very good but slow, reaching 30% after four weeks and 75% after eight weeks from sowing.

Plant uses

The fruit is edible. The stems are used for making tool handles and for poles. The roots are boiled and the liquid mixed with other medicines to treat venereal diseases.

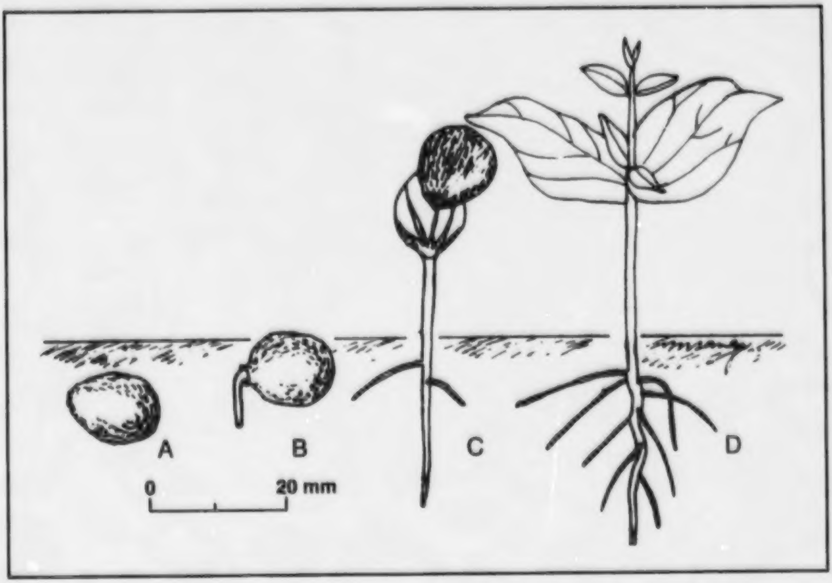


Figure 135. Stages in seed germination and early development of *Strychnos cocculoides* seedlings. (A) At sowing, (B) at 2 weeks, (C) at 4 weeks, (D) at 6 weeks after sowing.

Swartzia madagascariensis Desv.

LEGUMINOSAE: PAPILIONOIDEAE

Other names

Snake bean tree; kikonda (Kifipa); chigenye (Kimatengo); kasanda, nyegenye (Kinyamwezi).

Fruit morphology and seed extraction

The fruit is a long, cylindrical, dark brown pod, up to 30 cm long, straight or curved. It resembles a snake; hence the English name "snake bean". It contains 10 to 15 seeds in a sticky yellow tissue. The pods do not split open; they are dried in the sun and pounded in a mortar to extract seeds, which are cleaned by shaking and winnowing. A flailing thresher machine may also be used to extract seeds. About 8 kg of dry pods produce 1 kg of seeds.

Seed morphology

The seed is yellow, hard, and kidney-shaped, with rounded tips, about 6 mm long and 4 mm broad. There are about 9500 seeds per kilogram.

Seed storage

The seed is orthodox and can be stored for three years at room temperature without significant loss of viability, if kept dry and free of insects.

Seed presowing treatment

The hot water treatment is effective for this species (*see* section on seed presowing treatments).

Seed germination

Germination is epigeal (Figure 136). The radicle emerges first, then the hypocotyl elongates, bending, and carries the cotyledons above the germination medium. The seed coat usually remains, partly enclosing the cotyledons, until they separate and the seed coat falls off. Germination is very good and uniform, reaching 60% after 20 days and 80% after 25 days from sowing.

Plant uses

The termite-resistant wood is used for fence posts, and is also favoured by wood carvers when *Dalbergia melanoxylon* is not available. The wood is also used for firewood, charcoal and pestles. Crushed pods are used to protect grain in storage bins from weevils, and to prevent shoot borers in maize plants. Fishers use them to stupefy fish.

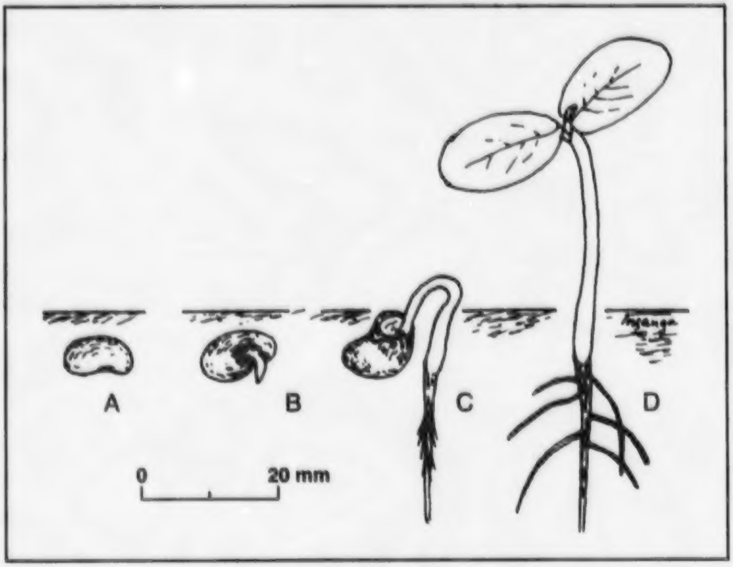


Figure 136. Stages in seed germination and early development of *Swartzia madagascariensis* seedlings. (A) At sowing, **(B)** at 5 days, **(C)** at 8 days, **(D)** at 18 days after sowing.

Syzygium cordatum Hochst.

MYRTACEAE

Other names

Waterberry, water tree; mzambarau mwitu (Kiswahili); mshihwi (Kisambaa); mlama (Kipare).

Fruit morphology and seed extraction

The fruit is a drupe, nearly spherical, two- to three-celled, about 2.0 cm long and 1.5 cm wide, green at first, turning reddish-purple when ripe. The ripe fruits are collected from the ground soon after natural shedding. They are squashed by hand to remove the skin and pulp around the seeds. The seeds are separated by floating the pulp and skin in water, while the filled seed sink.

For extraction of bulk quantities, the fruits are soaked in water, mixed with gravel in a proportion by weight of one part gravel and two parts fruits, and poured, together with large quantities of water, into a concrete mixer. After prolonged mixing, water, pulp, and fruits are poured off, leaving seeds and gravel at the bottom. The gravel is picked out by hand or separated from the seeds using a sieve with mesh just small enough to retain the gravel. The seeds are dried in the shade for one day, then cleaned using an air-screen machine. About 5 kg of fruits produce 1 kg of clean seed.

Seed morphology

The seed is yellowish to greenish, rounded, and about 1.3 cm in diameter; it has a brittle seed coat when dry. The embryo stalk is buried in a groove between two thick cotyledons. There are about 450 seeds per kilogram.

Seed storage

The seed is recalcitrant and should be packed in small quantities (less than 5 kg) in cotton bags or in gunny bags made of sisal or jute fibre. Alternatively, they can be kept in wire mesh trays under shade. Both methods provide good ventilation.

The seeds cannot tolerate desiccation below 25% moisture content, and should be stored at room temperature. Seeds should be sown within four weeks after collection.

Seed presowing treatment

The seed does not require pretreatment.

Seed germination

Germination is hypogeal (Figure 137). The seed coat cracks at the scar, and the radicle emerges and develops into a tap root. The epicotyl separates the cotyledons and elongates, leaving the cotyledons within the seed coat buried in the germination medium. Germination is very good and uniform, attaining 80% after four weeks and 90% after five weeks from sowing day.

Plant uses

A liquid extract of the leaf is taken as a remedy for stomach troubles and diarrhoea. A mixture of pounded leaf, bark and root is applied to the breasts of nursing mothers to increase milk flow. The powdered bark is used by fishers to stupefy fish. The stem and branches provide good firewood, especially for maintaining a fire. The aromatic wood smoke is used traditionally for smoking milk gourds. The fruits, which have a slightly acid flavour, are eaten. A purple dye is obtained from the fruits, and the flowers are important bee forage.

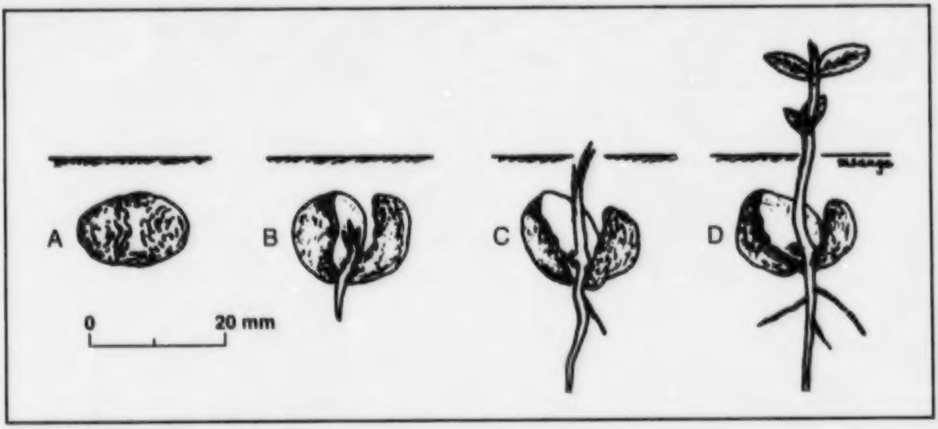


Figure 137. **Stages in the germination of *Syzygium cordatum* seed. (A)** At sowing, **(B)** at 20 days, **(C)** at 30 days, **(D)** at 40 days after sowing.

Syzygium guineense (Willd.) DC.
MYRTACEAE

Other names

Waterpear, waterberry; mzambarau mwitu (Kiswahili); muchwesi (Kihaya); mmasai (Kichaga); mshamongo (Kinyamwezi); mshihwi (Kisambaa); mlama (Kipare).

Fruit morphology and seed extraction

The fruit is a drupe, almost spherical, two- to three- celled, about 2.0 cm long and 1.5 cm wide, whitish-green at first, turning purple-black; juicy when ripe. Ripe fruits are picked from trees or collected from the ground soon after natural shedding. The fruits are macerated in water for about six hours, then squashed by hand to remove the skin and pulp around the seeds. The pulp and skin are floated in water and poured off, leaving clean seeds.

For extraction of bulk quantities, the soaked fruits are mixed with gravel in a proportion by weight of one part gravel and two parts fruits, and poured with large quantities of water into a concrete mixer. After mixing, water, pulp, and fruit skin are poured off, leaving seeds and gravel at the bottom. The gravel is picked out by hand or separated from the seeds by using a sieve with mesh just small enough to retain the gravel. The seeds are dried in the shade for one day, then cleaned using an air-screen cleaner. About 5 kg of fruits produce 1 kg of clean seed.

Seed morphology

The seed is yellowish to greenish, rounded, and about 1.3 cm in diameter; it has a brittle seed coat when dry. The embryo stalk is buried in a groove between two thick cotyledons. There are about 450 seeds per kilogram.

Seed storage

The seed is recalcitrant and should be packed in small quantities (less than 5 kg) in cotton bags or in gunny bags made of sisal or jute fibre. Alternatively, they can be kept in wire mesh trays under shade. Both methods provide good ventilation.

The seeds cannot tolerate desiccation below 25% moisture content, and should be stored at room temperature. Seeds should be sown within four weeks after collection.

Seed presowing treatment

The seed does not require pretreatment.

Seed germination

Germination is hypogeal (Figure 138). First the seed coat cracks at the scar, then the radicle emerges and develops into a taproot. The epicotyl separates the cotyledons, breaks through the seed coat and elongates, leaving the cotyledons within the seedcoat buried in the germination medium. Germination is very good and fairly uniform, attaining 80% after four weeks and 90% after five weeks from sowing.

Plant uses

The liquid obtained from boiled bark is used to treat dysentery, as is the fruit. The timber is suitable for shuttering and boxes. The stem and branches provide good firewood which is used particularly for maintaining fires. The aromatic wood-smoke is used traditionally for smoking milk gourds. The fruits are edible, and are a source of a purple dye. The flowers are important forage for bees.

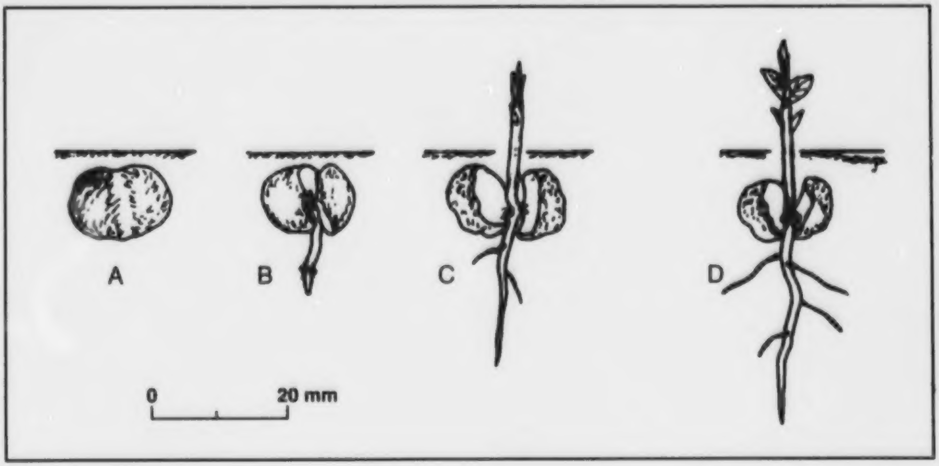


Figure 138. Stages in the germination of *Syzygium guineense* seed. (A) At sowing, **(B)** at 20 days, **(C)** at 30 days, **(D)** at 40 days after sowing.

Tamarindus indica L.

LEGUMINOSAE: CAESALPINIOIDEAE

Other names

Tamarind; mkwaju (Kiswahili); mkwazu (Kipare, Kisambaa, Kibondei); msisi (Kihehe, Kinyamwezi); bushishi (Kisukuma).

Fruit morphology and seed extraction

The fruit is a pod, usually curved, to 11 cm long, pale brown at all stages of development, skin soft at first, brittle and shell-like at maturity; each pod contains one to ten seeds joined by tough fibres running through a sticky pulp (Figure 139). Pods are sometimes constricted due to abortion of some seeds. Ripe pods are picked from the tree and dried in the sun. The pods are indehiscent, and are broken by light hammering. The seeds are embedded in pulp, which is scraped off with a knife, and the seeds are washed in water.

For bulk quantities, fruits are soaked in water in a plastic container for about six hours, then mixed with gravel (one part gravel to two parts fruits by weight) and large quantities of water in a concrete mixer. Water, pulp, skin, and empty seeds are poured off to leave filled seeds and gravel. Gravel is removed by sieving. Alternatively, a flailing thresher can be used. The seeds are dried in the sun for one to two days, and then cleaned with an air-screen cleaner. About 5 kg of fruits produce 1 kg of clean seeds.

Seed morphology

The seed is dark brown, about 1 cm long and 0.5 cm broad, terminating abruptly at the end. The seed coat is hard, glossy and smooth. Flat faces are marked by a line parallel with the outline of the seed. There are about 2600 seeds per kilogram.

Seed storage

The seed is orthodox and can be stored for four years at room temperature, if kept dry and free of insects.

Seed presowing treatment

Presowing treatments will increase both speed and germination percentage, although some untreated seed will germinate. Small quantities may be pretreated by using sandpaper or a hot wire (*see* section on seed presowing treatments). Bulk quantities may be pretreated using a seed gun at a speed which will give a crack index of about 40%. Soaking the seeds in cold water for six hours also hastens germination.

Seed germination

Germination is epigeal (Figure 140). The seed coat softens, and a jelly-like layer forms which serves to stick the seed to the soil. The radicle emerges and descends while the hypocotyl elongates, bending slightly, and rises above the germination medium. The seed coat falls off and the cotyledons, on exposure to light, change from white to green. The cotyledons remain folded against the stem. Germination is good and fairly uniform, attaining 50% after four weeks and 90% after five weeks from sowing.

Plant uses

The wood is used to make furniture, pounding utensils and boats; also for turnery, firewood and charcoal. Overripe fruits are used to polish copper and brass utensils. The fruit pulp is eaten raw or used to make a refreshing drink, valuable for treating fevers. The buds and foliage are also edible. The tree is used as an ornamental, and also for providing shade around homesteads, while the stem and branches provide poles for hut building and for making traditional walking sticks.

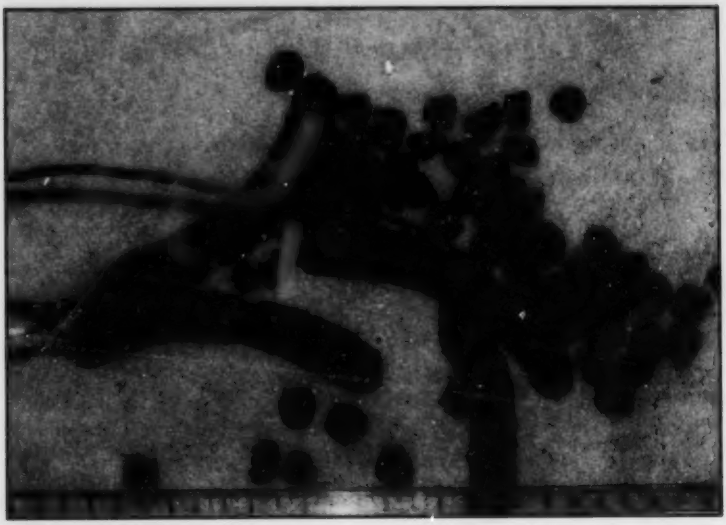


Figure 139. *Tamarindus indica* pods and seeds.

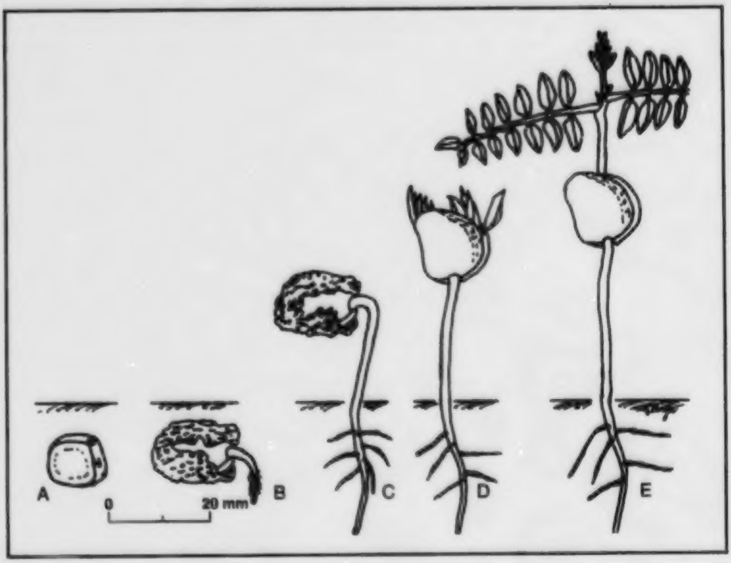


Figure 140. Stages in seed germination and early development of *Tamarindus indica* seedlings. (A) At sowing, (B) at 5 days, (C) at 15 days, (D) at 20 days, (E) at 30 days after sowing.

Tephrosia interrupta Hochst. ex Steud. subsp. *interrupta*

LEGUMINOSAE: PAPILIONOIDEAE

Other names

Kibaazi (Kiswahili); mkala wa nkoma, ipojo (Kipare).

Fruit morphology and seed extraction

The fruit is a pod, 8 cm long and 0.6 cm broad, covered with silky hairs, and containing several seeds. The pods should be dried in the sun for a few days, then threshed in a gunny bag using a stick. Seeds are cleaned by shaking and winnowing. About 15 kg of dry pods produce 1 kg of seeds.

Seed morphology

The seed is kidney-shaped, with rounded tips and a white scar. The seed coat is black and hard. The seed is small, 4 mm long and 3 mm broad. There are about 90 000 seeds per kilogram.

Seed storage

The seed is orthodox and can be stored for two years at room temperature without significant loss of viability, if kept dry and free of insects.

Seed presowing treatment

Fresh seeds germinate readily without treatment. Stored seeds should be treated by the hot water method (*see* section on seed presowing treatments).

Seed germination

Germination is epigeal (Figure 141). The radicle emerges first, then the hypocotyl elongates, bending, and carries the cotyledons above the germination medium. The seed coat usually remains partially enclosing the cotyledons until they separate and it falls off. The cotyledons change from white to green but later become brown and shrivelled. Germination is very good and moderately uniform, reaching 5% after 10 days and 80% after 21 days from sowing.

Plant uses

The plant is nitrogen-fixing, and suitable for green manuring and intercropping with agricultural crops. It is also ornamental, with beautiful purple flowers, and may be planted near houses.

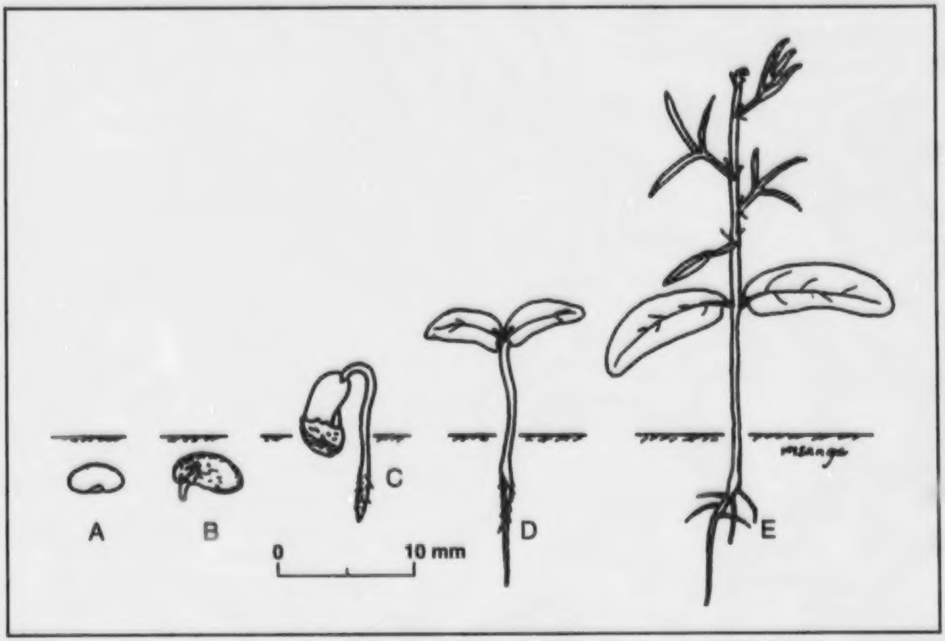

A
B
C
D
E
0
10 mm
Msanga

Figure 141. **Stages in seed germination and early development of *Tephrosia interrupta* seedlings.** (A) At sowing, (B) at 3 days, (C) at 10 days, (D) at 20 days, (E) at 3 months after sowing.

Tephrosia vogelii Hook. f.

LEGUMINOSAE: PAPILIONOIDEAE

Other names

Utupa, kibaazi (Kiswahili); mkala, mdomboza (Kipare).

Fruit morphology and seed extraction

The fruit is a pod, densely covered with short smooth hairs, about 11 cm long, 1.5 cm broad, and 4 mm thick. It has a slightly curved beak, and contains up to 20 seeds. Dry pods should be threshed in a gunny bag with a stick. Seeds are cleaned by winnowing. About 13 kg of fruits produce 1 kg of seeds.

Seed morphology

The seed is bean-shaped, black, smooth, about 5 mm long and 3 mm broad, and compressed. It has round tips, a hard seed coat, a scar at the side of the narrow end, and a well-marked annular aril. There are about 80 000 seeds per kilogram.

Seed storage

The seed is orthodox and can be stored for one year at room temperature, if kept dry and free of insects.

Seed presowing treatment

Fresh seeds germinate readily without treatment. Stored seeds should be treated by the hot water method (*see* section on seed presowing treatments).

Seed germination

Germination is epigeal (Figure 142). The radicle emerges first, near the scar, then the hypocotyl elongates, bending, and carries the cotyledons above the germination medium. The seed coat usually remains partially enclosing the cotyledons until they separate and it falls off.

Germination is good and moderately uniform, reaching 10% after 12 days and 75% after 25 days from sowing.

Plant uses

The leaves are used by fishers to stupefy fish; pounded leaves and bark yield a mosquito repellent and an insecticide. The plant is grown for wind-breaks and for mulch, and its beautiful red, white, or violet-purple flowers render it an attractive ornamental. In north-eastern Tanzania this species is cultivated in farmland by the Wapare people to control *Armillaria mellea*, a root-rot disease of many crops.

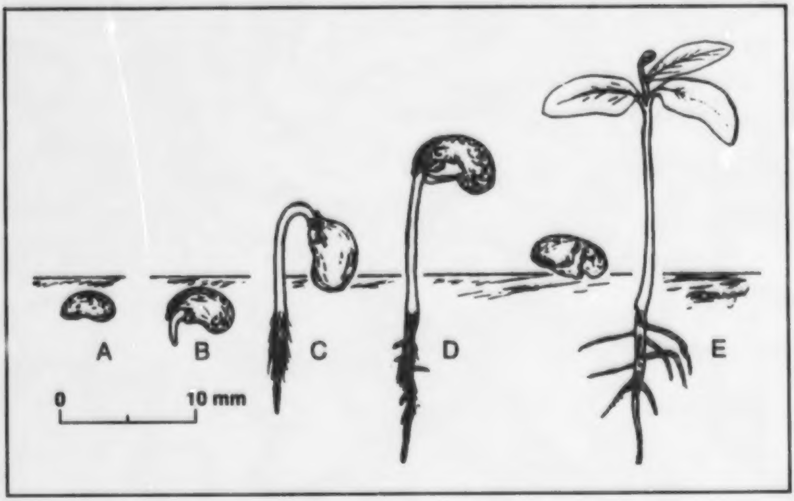


Figure 142. **Stages in seed germination and early development of *Tephrosia vogelii* seedlings. (A)** At sowing, **(B)** at 4 days, **(C)** at 10 days, **(D)** at 15 days, **(E)** at 6 weeks after sowing.

Terminalia sericea Burch. ex DC.
COMBRETACEAE

Other names

Silver terminalia; mpululu (Kinyamwezi, Kihehe, Kinyiramba); mpini (Kiswahili).

Fruit morphology and seed extraction

The fruit is a dry drupe, 4 cm long, flat, and winged around the central seed. Colour ranges from purple-brown to pink-purple. Seed extraction is difficult and not recommended; seeds are fragile and many fruits are empty.

Seed morphology

The seed is flat, elongated, about 2.5 cm long, and is not usually removed from the fruit. There are about 1700 de-winged fruits per kilogram.

Seed storage

The seed is orthodox and can be stored for up to three years at room temperature without significant loss of viability, if kept dry. However it is recommended that seed be sown within one year after collection.

Seed presowing treatment

Fruits should be de-winged and soaked in cold water for six hours to soften the endocarp and leach out chemicals suspected to be germination inhibitors.

Seed germination

Germination is intermediate between epigeal and hypogeal (Figure 143). The seed coat softens as the seed absorbs water. The radicle emerges at one end of the seed and descends to form a taproot. The hypocotyl is very short, and the cotyledonary stalks remain partly submerged in the germination medium. The hypocotyl bends slightly in emerging from the seed but soon straightens. The two leafy cotyledons unfold and expand greatly, and change colour from white to green. The endocarp splits into two parts and remains in the germination medium.

Germination is good but sporadic. It attains 20% after 10 days and 60% after 30 days.

Plant uses

The wood is suitable for firewood, charcoal, timber, poles, and tool handles, hence the Kiswahili name "mpini". The bark is used to make rope and a red dye. The tree is often planted for shade or beautification along roads.

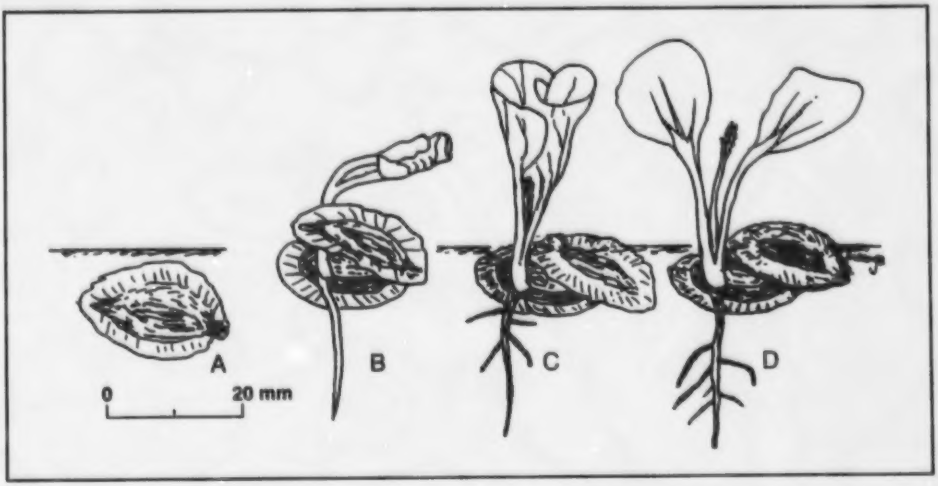


Figure 143. **Stages in seed germination and early development of *Terminalia sericea* seedlings.** **(A)** At sowing, **(B)** at 7 days, **(C)** at 10 days, **(D)** at 15 days after sowing.

Treculia africana Decne.
MORACEAE

Other names

African bread fruit, wild jackfruit; ezeya, mjaya (Kiluguru); mbungu (Kihaya); maya (Kimatengo).

Fruit morphology and seed extraction

The compound fruit (formed by many united small fruits) is round, very large, up to 30 cm across, and contains about 7 000 seeds buried in spongy pulp. The outer surface is covered with rough pointed outgrowths. The fruit is squashed by hand to squeeze the seed out of the pulp. After mixing with water, the pulp, fruit skin, and empty seeds are poured off, leaving clean, filled seeds.

Seed morphology

The seed is almost egg-shaped, about 11 mm long and 7 mm broad, soft, and creamy-white, with a thin papery seed coat. There are about 4300 seeds per kilogram.

Seed storage

The seed is recalcitrant and should be packed in small quantities (less than 5 kg in cotton bags) in order to provide good ventilation. It cannot tolerate desiccation below 20% moisture content or freezing temperatures. Seeds should be sown within four weeks after extraction.

Seed presowing treatment

The seed does not require any pretreatment.

Seed germination

Germination is epigeal (Figure 144). The radicle emerges through the scar and pushes its way downwards. The hypocotyl elongates, bending greatly, and carries the cotyledons above the germination medium. The seed coat persists for a while on the cotyledons.

Germination is very good and fast, reaching 70% after 10 days and 100% after 15 days from sowing.

Plant uses

The tree provides firewood and timber, and is useful for soil conservation. The seeds can be dried, fried and eaten.

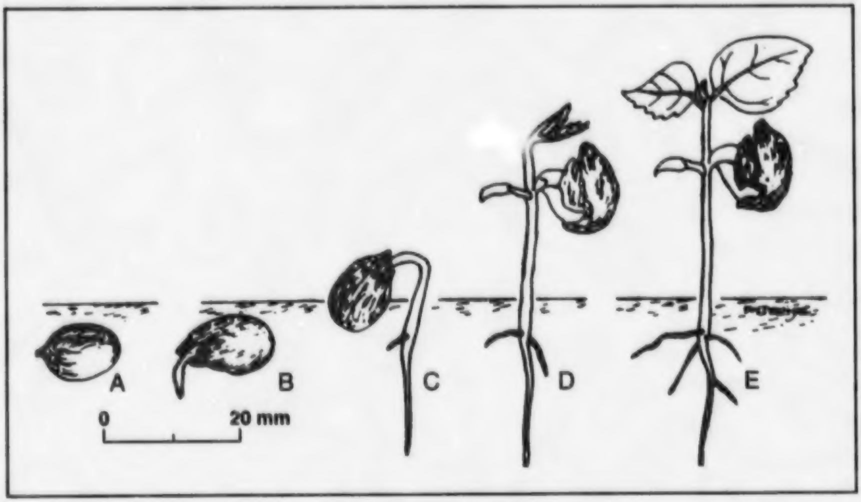


Figure 144. **Stages in seed germination and early development of *Treculia africana* seedlings. (A)** At sowing, **(B)** at 5 days, **(C)** at 8 days, **(D)** at 10 days, **(E)** at 14 days after sowing.

Trichilia emetica Vahl

Syn. *Trichilia roka* (Forssk.) Chiov.

MELIACEAE

Other names

Woodland mahogany; mafura, mkungwina, mtimaji (Kiswahili); mkoromaji (Kipare); mkongoni (Kichaga); mgolimasi (Kisambaa, Kizigua, Kinguu); sanguti (Kinyakyusa); mjagengo (Kiluguru); mbangwe (Kisambaa).

Fruit morphology and seed extraction

The fruit is a globular capsule, about 2.5 cm in diameter (Figure 145). At maturity the capsule wall splits slowly into three parts, exposing about six seeds. The ripe fruits are picked from trees and spread on sheeting material under shade for two days or more, until all the fruits have opened. The seeds are removed by hand. Extracted seeds are immersed in water to separate the floating empty seeds and debris from the sound seeds, which sink. These are spread in thin layers on wire mesh trays in the shade for two days to dry remaining surface water. About 4 kg of fruits produce 1 kg of seeds.

Seed morphology

The seed is black, about 20 mm long and 8 mm wide, slightly flattened, and almost completely enveloped in a bright red aril. There are about 1340 seeds per kilogram.

Seed storage

The seed is recalcitrant and should be packed in small quantities (less than 5 kg) in cotton bags or in gunny bags made of sisal or jute. Alternatively they can be kept in wire mesh trays under shade. Both methods provide good ventilation. The seeds cannot tolerate desiccation below 20% moisture content and should be stored at room temperature. Seeds should be sown within four weeks of collection.

Seed presowing treatment

Complete removal of the aril is advised. It can be removed by soaking the seeds in water for six hours, then squashing gently and washing in water. The seeds should be sown immediately; a delay of just a few days will reduce viability.

Seed germination

Germination is epigeal (Figure 146). The radicle emerges from the scar side and develops into a tap root. The hypocotyl extends, separating the two cotyledons and breaking through the seed coat. The aril (if not removed) usually decays while the seed coat is carried above the germination medium on the cotyledons, which change from white to green and remain attached to the seedlings. With complete removal of the aril, germination is very good and fairly uniform, attaining 5% after 10 days and 95% after 20 days from sowing.

Plant uses

A suspension of the squashed aril is used for cooking. Oil extracted from the seed kernel is used commercially for making soap, cosmetics and candles. The oil is also used to treat leprosy, fractures and rheumatism. The bark and leaves are used to treat dysentery, lumbago, bruises, and fever; they are also used as an emetic. An infusion of pounded bark is used to treat pneumonia. A decoction of the roots is taken as an anthelmintic, and to treat colds and persistent barrenness; it is also used to induce labour in pregnant women. The seed oil and pounded bark soaked in water are applied to sores, ringworm and other skin diseases. The tree is used in agroforestry systems to provide shade, fuelwood, poles and timber. It is often planted for shade or beautification along roads.

Figure 145. *Trichilia emetica* fruit and seeds.

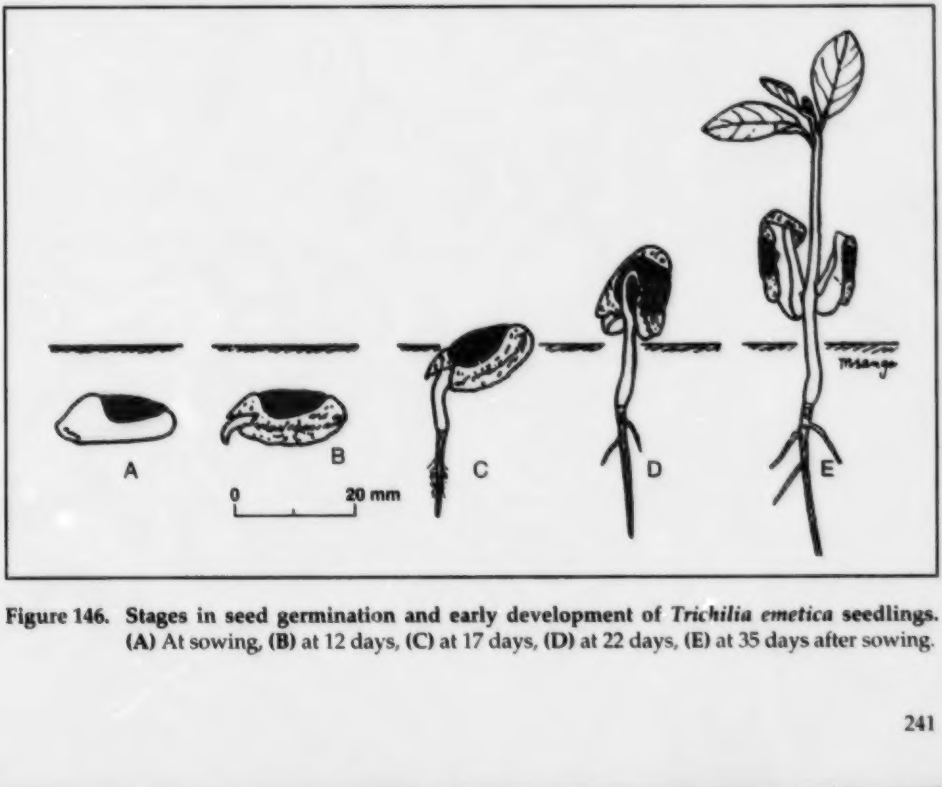


Figure 146. **Stages in seed germination and early development of *Trichilia emetica* seedlings.** **(A)** At sowing, **(B)** at 12 days, **(C)** at 17 days, **(D)** at 22 days, **(E)** at 35 days after sowing.

Turraea robusta Gürke
MELIACEAE

Other names

Msacha (Kipare); mdayo, (Kisambaa); mliandege (Kichaga); mkirika (Kiluguru); mgweja meno (Kizigua).

Fruit morphology and seed extraction

The fruit is a rounded capsule, about 1 cm across, with 10 to 15 cells; each cell contains one seed. Capsules and cells are broken by hand to release the seeds. About 6 kg of fruits produce 1 kg of seeds.

Seed morphology

The seed is black, shiny, about 5 mm long and 2.5 mm broad, with a fleshy yellow aril at the base. There are about 25 000 seeds per kilogram.

Seed storage

The seed is recalcitrant and should be packed in small quantities (less than 5 kg) in cotton bags. The seeds do not tolerate desiccation below 15% moisture content and should not be stored at freezing temperatures. They should be sown within six weeks after collection.

Seed presowing treatment

The seed does not need any pretreatment, but the aril must be removed.

Seed germination

Germination is epigeal (Figure 147). The radicle emerges from the scar end of the seed and pushes its way downwards. The hypocotyl elongates and raises the cotyledons above the germination medium. The cotyledons enlarge and split the seed coat, which later falls off.

Germination is poor, attaining 5% after 20 days and only 20% after 35 days.

Plant uses

The wood is used for making spoons and porridge stirrers, but the fruit and leaves are poisonous.

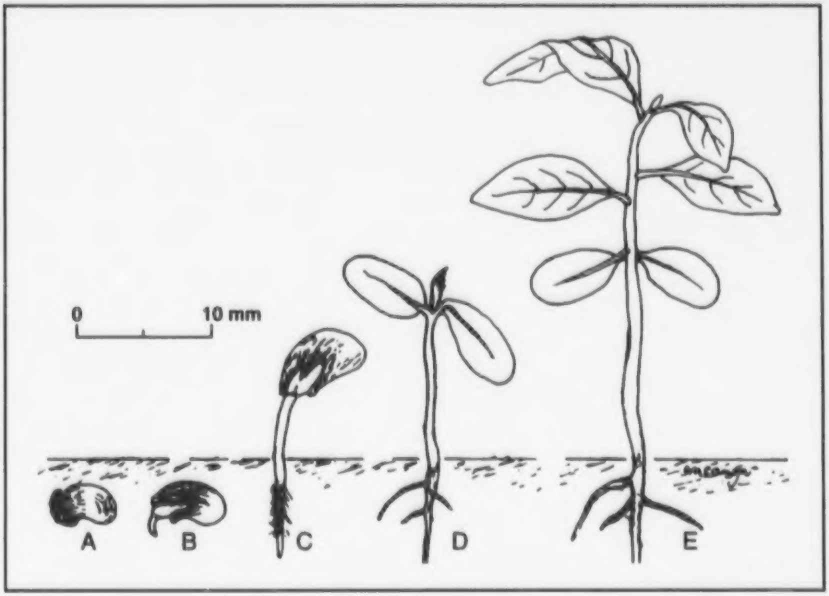


Figure 147. **Stages in seed germination and early development of** ***Turraea robusta*** **seedlings. (A)** At sowing, **(B)** at 2 weeks, **(C)** at 3 weeks, **(D)** at 4 weeks, **(E)** at 8 weeks.

Uapaca kirkiana Müll. Arg.

EUPHORBIACEAE

Other names

Mkusu (Kiswahili, Kibende, Kihehe, Kinyamwezi); msuku (Kingoni).

Fruit morphology and seed extraction

The fruit is a round fleshy berry; 2.5 to 3 cm in diameter; fine hairs cover it at first but disappear by maturity. The hard yellow skin surrounds a sweet fleshy pulp containing up to four seeds. The fruits are soaked in water for about six hours until they are soft and somewhat imbibed. They are then broken by hand to release the pulp and seeds. The fruit skin and pulp are separated from the seeds by squeezing and gently squashing in water. The seeds which sink are retained and spread in thin layers on wire mesh trays in the shade for one day, to dry surface water. About 4 kg of fruits produce 1 kg of seeds.

Seed morphology

The seed is white, about 2 cm long and 1.5 cm broad, with a rather brittle seed coat. One side is almost flat; on the opposite side there is a longitudinal ridge terminating with a sharp edge at the base. The seed has an inner membrane, endosperm, and two leafy green cotyledons. There are about 2500 seeds per kilogram.

Seed storage

The seed is recalcitrant and should be packed in small quantities (less than 5 kg) in cotton bags or in jute sacks. For transportation these small bags should be packed in a large cardboard box with holes to provide ventilation.

Seeds cannot tolerate desiccation below 26% moisture content and should not be stored at freezing temperatures. Seeds should be sown within two weeks after collection.

Seed presowing treatment

The seed does not require pretreatment, but soaking in cold tap water for six hours hastens germination.

Seed germination

Germination is intermediate between epigeal and hypogeal (Figure 148). The seed coat cracks and the radicle protrudes from the scar end and develops into a taproot. The seed coat splits longitudinally into equal halves, and the two leafy cotyledons unfold and expand greatly. The hypocotyl is very short and the cotyledons remain partly submerged in the germination medium.

Germination is good and fairly uniform with fresh seed. It reaches 30% after four weeks and 70% after six weeks from sowing.

Plant uses

The fruit is eaten raw and is also used for making a local brew. In Zambia and Malawi "msuku" and "mlungusi" wines are made from the fruit. The tree provides firewood, poles and general purpose timber.

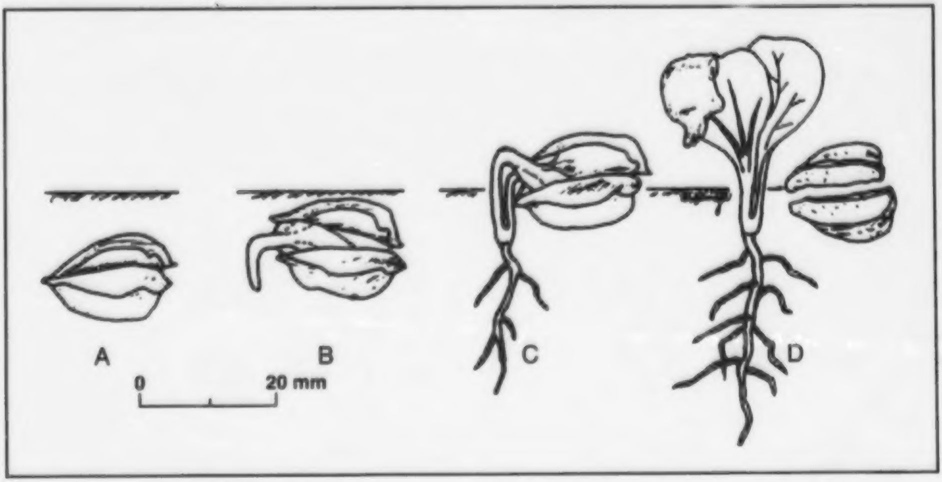


Figure 148. Stages in the germination of *Uapaca kirkiana* seed. (A) At sowing, **(B)** at 15 days, **(C)** at 20 days, **(D)** at 30 days after sowing.

Vangueria infausta Burch. subsp. *rotundata* (Robyns) Verdc.

Syn. *Vangueria tomentosa* Hochst.

RUBIACEAE

Other names

Wild medlar; muviru (Kiswahili); mdaria (Kipare); msada (Kinyamwezi, Kihehe, Kiluguru); mvilu, mviu (Kisambaa, Kibondei, Kizigua); ndawiro (Kichaga).

Fruit morphology and seed extraction

The fruit is a fleshy drupe, 3 to 4.5 cm long and 3.5 to 6 cm wide, bearing a shallow ring (the remains of the calyx), and covered with a greenish leathery skin which turns light brown when ripe (Figure 149). Within the fruit there are five seeds or sometimes fewer, as a result of abortion.

Ripe fruits dry up and persist on the tree for a considerable time; they are picked off. The skin and pulp are removed with a knife and the seeds washed in water. Seeds which float may also germinate, so are not discarded. For extraction of bulk quantities of seed the fruits are soaked in water for about six hours until soft and somewhat imbibed. They are then mixed with sharp gravel in a proportion by weight of one part gravel and two parts fruit. Together with large quantities of water, the fruit and gravel are mixed in a concrete mixer for some time until the seeds have separated from the pulp and skin. Then water, macerated pulp and broken pieces of skin are poured off, leaving seeds and gravel. The gravel is picked out by hand and the seeds dried in the sun for one to two days and then cleaned using an air-screen cleaner. About 5 kg of fruits produce 1 kg of clean seeds.

Seed morphology

The seed is almost egg-shaped, with a low ridge above the scar; it is yellowish brown, about 2.5 cm long and 1.5 cm broad. The seed coat is rough, hard and woody. The embryo is enclosed in a fleshy endosperm. There are about 500 seeds per kilogram.

Seed storage

The seed is orthodox and can be stored for two years at room temperature without significant loss of viability, if kept dry.

Seed presowing treatment

The seeds are manually pretreated. Light hammering with a knife handle or piece of metal splits the seed coat at the root end. Untreated seeds will also germinate, but require a prolonged period.

Seed germination

Germination is intermediate between hypogeal and epigeal (Figure 150). The endosperm and embryo enlarge following imbibition and cause the seed coat to burst at the root end. The radicle and the cotyledons elongate greatly and both emerge through the root end, rather than through the scar, as the embryo is oriented transversely. The radicle develops into a stout vigorous taproot while the epicotyl and first leaves push themselves up between the cotyledons. The hypocotyl is very short and the cotyledons remain partly submerged in the germination medium. On exposure to light they become green and remain attached to the seedling. The seed coat may remain partly enclosing the cotyledons, together with the shrivelled endosperm, or may fall off.

Germination is good but sporadic. It attains 15% after 23 days and 70% after 40 days from sowing.

Plant uses

The fruits and seed kernels are edible and are in high demand in local markets. A decoction of the roots is used medicinally to treat many complaints, including malaria, pneumonia, stomach congestion, hernias, menstrual troubles, coughs, chest problems, and roundworms. The stem is used for making handles, digging tools, and spring traps, and for hut building.

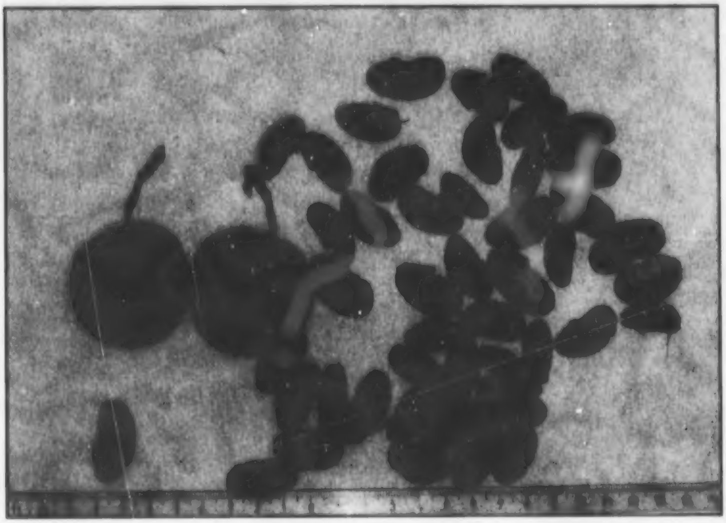


Figure 149. ***Vangueria infausta*** **fruit and seeds.**

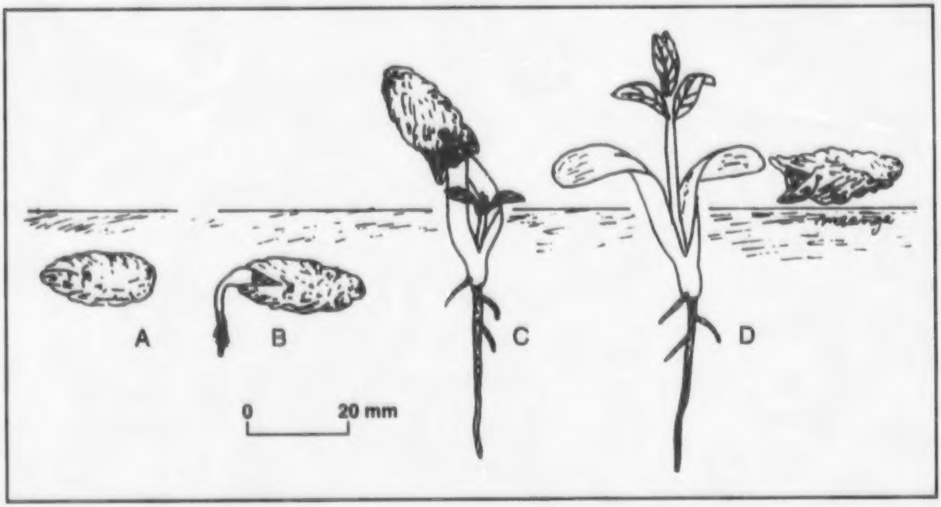


Figure 150. **Stages in the germination of** ***Vangueria infausta*** **seed. (A)** At sowing, **(B)** at 15 days, **(C)** at 25 days, **(D)** at 35 days after sowing.

Vitex doniana Sweet
VERBENACEAE

Other names

Black plum; mfuru (Kiswahili).

Fruit morphology and seed extraction

The fruit is a drupe, roughly parallel-sided, about 1.5 cm long, with a more or less fleshy mesocarp (pulp) and a hard-celled endocarp (nut). The fruit has rounded edges, and is shiny and black when ripe. For extraction of small quantities, the skin and pulp are removed with a knife and the nuts are washed in water. For large quantities, the fruit may be soaked in water for 24 hours then mixed with gravel in a proportion by weight of one part gravel and two parts fruit. Together with large quantities of water they are mixed in a concrete mixer for some time. Then water, pulp and broken skin are poured off. The gravel is picked out by hand. Another method is to soak the fruit in water for 24 hours. Then seed can be extracted using a flailing thresher. A fourth method is to dry the fruit in the sun for several days, then mix with gravel (as for the second method) and process the mixture, without water, in a concrete mixer for some time. The gravel can be picked out by hand and the seeds cleaned by an air-screen machine. About 5 kg of fruits produce 1 kg of nuts.

Seed morphology

The nut is very hard, slightly elongated, with a rounded apex at the side opposite the base, about 1.5 cm long and 1 cm broad. Each nut contains one to four seeds, each with a thin membraneous seed coat. For practical purposes each nut is considered as a seed. There are about 2000 nuts per kilogram.

Seed storage

Properly dried nuts can be stored for two years at room temperature without significant loss of viability.

Seed presowing treatment

The nuts should be soaked in cold water for 24 hours, changing the water after 12 hours.

Seed germination

Germination is epigeal (Figure 151). The cotyledons expand and cause the nut to burst, starting at the scar end. The radicle develops and the hypocotyl bends and elongates, carrying the cotyledons above the germination medium. The nut remains in the germination medium. One nut may produce four seedlings, or fewer, due to abortion.

Germination is good but sporadic. It reaches 30% after five weeks and 60% after eight weeks from sowing.

Plant uses

The fruit is sweet and edible. The timber is used for building boats and houses, and making crates and furniture.

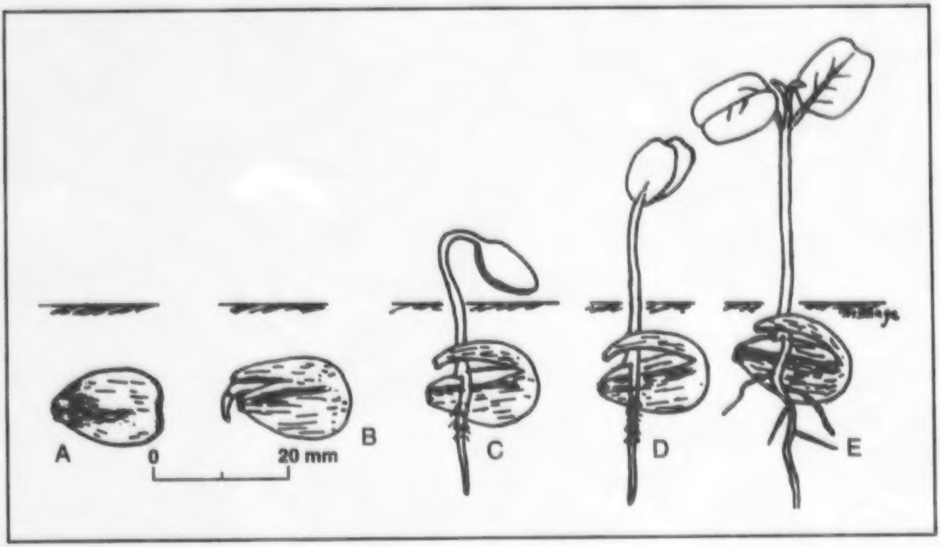


Figure 151. Stages in seed germination and early development of *Vitex doniana* seedlings. (A) At sowing, (B) at 4 weeks, (C) at 5 weeks, (D) at 6 weeks, (E) at 7 weeks after sowing.

Vitex keniensis Turrill

VERBENACEAE

Other names

Meru oak; mfuru (Kiswahili).

Fruit morphology and seed extraction

The fruit is a drupe, roughly parallel-sided, about 1.5 cm long, with a more or less fleshy mesocarp (pulp) and a hard-celled endocarp (nut). The fruit has rounded edges, and is shiny and black when ripe. With small quantities, the fruit skin and pulp are removed using a knife and the nuts are washed in water. For extraction of large quantities, the fruit may be soaked in water for 24 hours then mixed with gravel in a proportion by weight of one part gravel and two parts fruit. Together with large quantities of water they are mixed in a concrete mixer for some time. Then water, pulp and broken skin are poured off, and the gravel is picked out by hand. Another method is to soak the fruit in water for 24 hours. Then seed can be extracted using a flailing thresher. A fourth method is to dry the fruit in the sun for several days, then mix them with gravel (as for the second method) and process the mixture, without water, in a concrete mixer for some time. The gravel can be picked out by hand and the seeds cleaned by an air-screen machine. About 5 kg of fruits produce 1 kg of nuts.

Seed morphology

The nut is very hard, slightly elongated, with a rounded apex at the side opposite the base, about 1.3 cm long and 1 cm broad. Each nut contains one to four seeds, each with a thin membraneous seed coat. For practical purposes each nut is considered as a seed. There are about 2500 nuts per kilogram.

Seed storage

Seed is orthodox; properly dried nuts can be stored for two years at room temperature without significant loss of viability.

Seed presowing treatment

The nuts should be soaked in cold water for 24 hours, changing the water after 12 hours.

Seed germination

Germination is epigeal (Figure 152). The cotyledons expand and cause the nut to burst, starting at the scar end. The radicle develops, and the hypocotyl bends and elongates, carrying the cotyledons above the germination medium. The nut remains in the germination medium. One nut may produce four seedlings, or fewer, due to abortion.

Germination is good but sporadic. It reaches 4% after five weeks and 60% after seven weeks from sowing.

Plant uses

The timber is used for furniture and general construction.

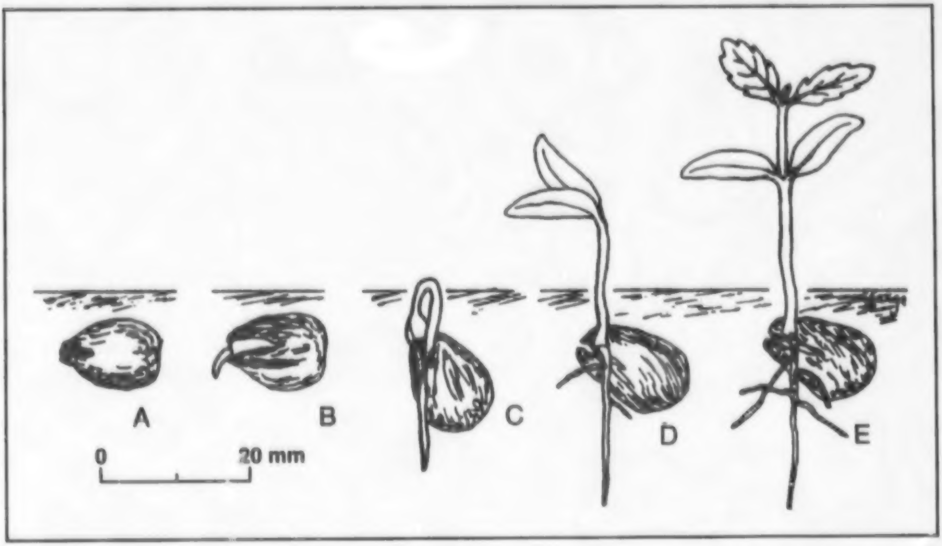


Figure 152. **Stages in seed germination and early development of *Vitex keniensis* seedlings. (A)** At sowing, **(B)** at 2 weeks, **(C)** at 3 weeks, **(D)** at 4 weeks, **(E)** at 5 weeks after sowing.

Voacanga africana Stapf
APOCYNACEAE

Other names

Mwambe (Kisambaa); mlembelembe (Kiluguru).

Fruit morphology and seed extraction

The fruits are paired capsules, each part almost spherical, 5.5 cm in diameter, greenish with raised, cream markings. Ripening fruits are picked from the tree, and the paired lobes are opened by hand to release the pulp and about 20 seeds. The pulp is separated from the seeds by gently squashing in water, and the seeds are dried in the sun. About 15 kg of fruits produce 1 kg of seeds.

Seed morphology

The seed is light brown, thickest in the middle and narrowing towards each end, about 7 mm long and 4 mm broad, with a deep longitudinal margin on one side. There are about 10 000 seeds per kilogram.

Seed storage

Seed is intermediate between orthodox and recalcitrant, and should be kept in a cool (2–5°C), dry place. Where such conditions are not available, seeds can be kept at ambient air temperature, out of direct sunshine. Seeds should be sown within 12 months after collection.

Seed presowing treatment

The seed does not require any pretreatment.

Seed germination

Germination is epigeal (Figure 153). The radicle emerges from one end and develops into a taproot. The hypocotyl elongates, bending, and carries the cotyledons above the germination medium. The cotyledons unfold, split the seed coat, and change colour from white to green. The seed coat later falls off.

Germination is very good but sporadic. It attains 50% after four weeks and 90% after seven weeks from sowing.

Plant uses

A drug to lower blood pressure is extracted from the seeds, and the plant is also a source of a drug used to treat cancer and heart diseases. The latex is mixed with that of *Ficus* spp. in making birdlime.

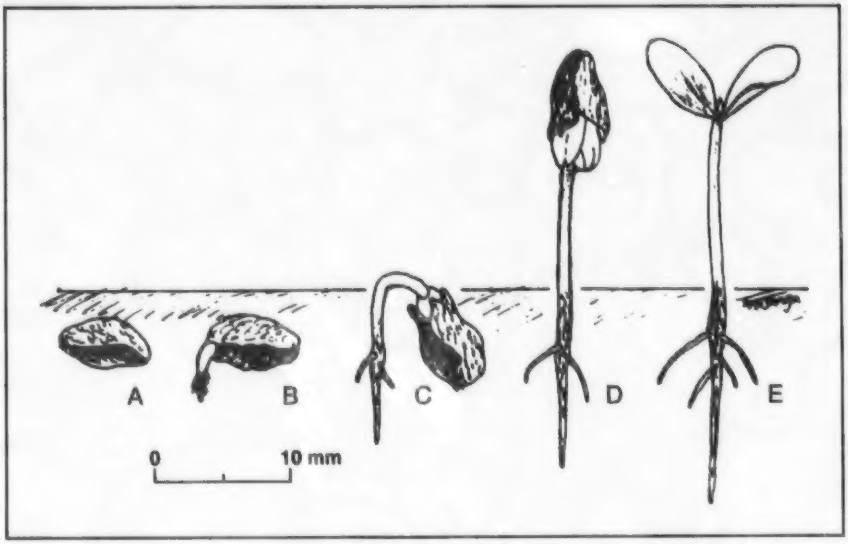


Figure 153. Stages in the germination of *Voacanga africana* seed. (A) At sowing, **(B)** at 10 days, **(C)** at 20 days, **(D)** at 25 days, **(E)** at 30 days after sowing.

***Warburgia salutaris* (Bertol. f.) Chiov.**

Syn. *Warburgia ugandensis* Sprague

CANELLACEAE

Other names

East African greenheart, pepper bark; mgambo, (Kipare); mdele, mlifu (Kisambaa); mkaa, mkarambaki (Kiswahili); ol-sokoni (Kimasai); mhija (Kihaya).

Fruit morphology and seed extraction

The fruit is a capsule, green at first, turning purplish when ripe, almost round, and about 1 cm in diameter. Ripe fruits are collected from the tree and the leathery skin split into two lobes by hand to release the seeds. Each fruit contains about five seeds. About 5 kg of fruits produce 1 kg of seeds.

Seed morphology

The seed is compressed, about 5 mm long, almost heart-shaped, and yellow-brown. The surface is glossy and coated with a thin layer of oil. There are about 24 000 seeds per kilogram.

Seed storage

The seed is recalcitrant, and should be kept in a cool (2–5°C), dry place. Where this is not possible, seeds can be kept at ambient air temperature, out of direct sunshine. Seeds should be sown within two months of collection.

Seed presowing treatment

No pretreatment has been tested. The seed coat is thin, and is unlikely to play a significant role in dormancy. The long germination periods suggest that pretreatments to break embryo dormancy, such as stratification, should be investigated.

Seed germination

Germination is epigeal (Figure 154). The seed expands slightly and ruptures the seed coat. The radicle emerges and pushes downwards. The hypocotyl elongates, bending greatly, and carries the cotyledons above the germination medium. Later the cotyledons expand and emerge from the seed coat.

Germination is very good and moderately uniform but delayed. It reaches 40% after four weeks and 95% after seven weeks from sowing.

Plant uses

The wood is used for cabinet making, turnery and furniture; it also yields aromatic oil used in perfumes. The resin is used locally to fix tool handles. Dried bark is chewed and the juice swallowed as a remedy for stomach-ache, constipation, coughs, colds, fever, muscle pains, weak joints and general body pains. The powdered bark is mixed with water and used for toothache. Fresh roots are boiled and the decoction mixed into soup which is drunk for the prevention of diarrhoea, and a boiled decoction of the leaves is used as a topical treatment for several skin diseases.

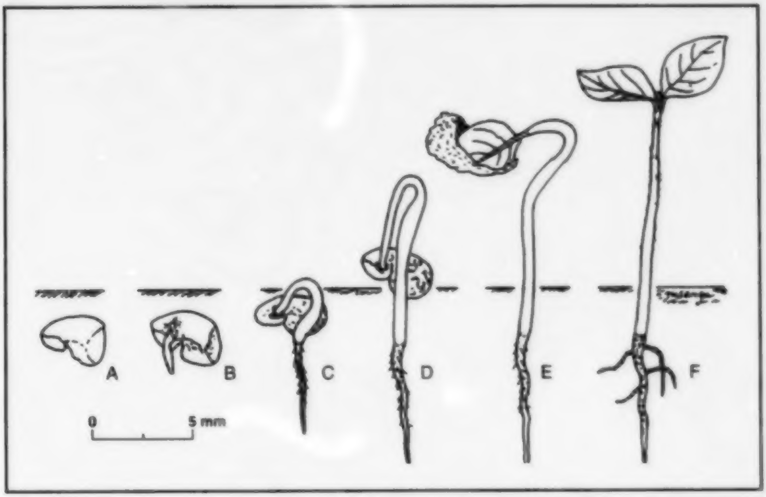


Figure 154. **Stages in seed germination and early development of *Warburgia salutaris* seedlings. (A)** At sowing, **(B)** at 25 days, **(C)** at 30 days, **(D)** at 32 days, **(E)** at 40 days, **(F)** 45 days after sowing.

Xeroderris stuhlmannii (Taub.) Mendonça & E.C. Sousa

LEGUMINOSAE: PAPILIONOIDEAE

Other names

Wing pod; mondogondo (Kiswahili); mnyinga (Kigogo); munyenye (Kinyamwezi); njundu (Kisukuma); munene (Kinyiramba).

Fruit morphology and seed extraction

The pods are linear with rounded ends, indehiscent, up to 14 cm long and 3 cm wide, with a distinct, raised edge running around the pod, slightly within the margin; a narrow "wing" extends down each side. Pods are light green at first, turning light brown when ripe. Each pod usually contains one to three seeds.

There are two methods of seed extraction. The first is to soften the pods by soaking them in water for 12 hours. They can then be broken open, by hand or secateurs, to release the seeds. The second method is to use a flailing thresher machine when the pods are dry, and clean the seeds with an air-screen cleaner. About 8 kg of pods produce 1 kg of seeds.

Seed morphology

The seeds are about 10 mm long and 6 mm broad, light brown, and smooth, with rounded tips and a small depression at the scar. There are about 2300 seeds per kilogram.

Seed storage

The seed is orthodox and can be stored for up to two years at room temperature without significant loss of viability, if kept dry and free of insects.

Seed presowing treatment

The seed does not require pretreatment.

Seed germination

Germination is epigeal (Figure 155). The seed coat softens as the seed absorbs water, and the cotyledons swell and rupture the seed coat. The radicle emerges just above the scar and descends. The hypocotyl elongates and carries the seed coat and cotyledons above the germination medium. Later the cotyledons expand and separate, and the seed coat falls off.

Germination is very good and uniform, reaching, on average, 70% after seven days and 95% after 12 days from sowing.

Plant uses

The wood is used for railway sleepers and locally for grain mortars, traditional beehives, stools, and firewood. A red dye is obtained from the resinous sap. The leaves and pods are good fodder for livestock.

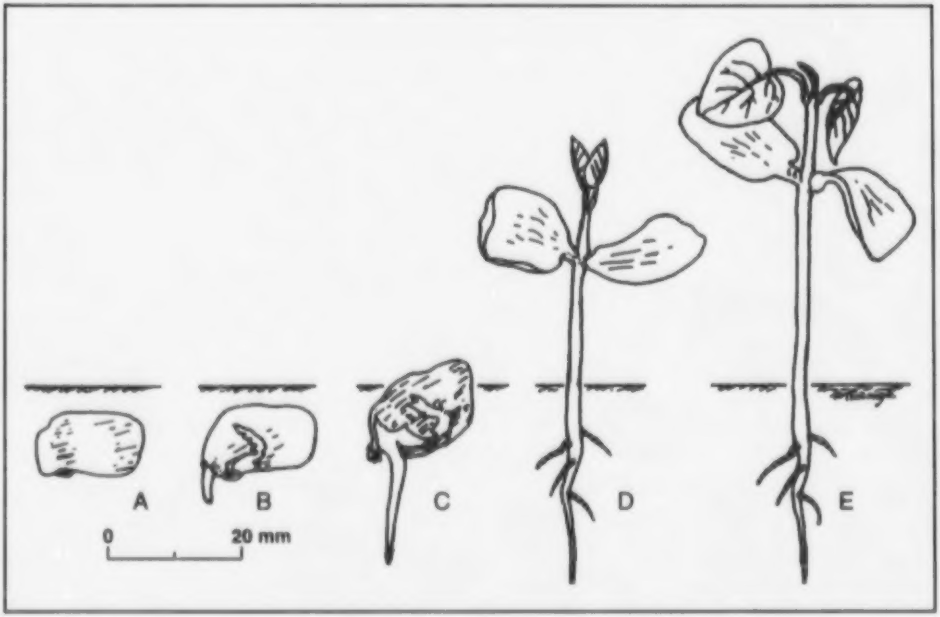


Figure 155. **Stages in seed germination and early development of *Xeroderris stuhlmannii* seedlings. (A)** At sowing, **(B)** at 4 days, **(C)** at 7 days, **(D)** at 10 days, **(E)** at 15 days after sowing.

Ximenia americana L.

OLACACEAE

Other names

Wild plum; msantu (Kichaga); mtundakula (Kiswahili); mtundwa, mpingi (Kisukuma, Kinyamwezi); mntundutwa (Kipare).

Fruit morphology and seed extraction

The fruit is an oval drupe, up to 2.5 cm long, yellow-pink-red, with one large seed. Fruits are soaked in water for six hours, and then squeezed by hand or rubbed on a wire mesh to release the seeds from the pulp. Seeds are washed in water. About 5 kg of fruits produce 1 kg of seeds.

Seed morphology

The seed is egg-shaped, about 1.8 cm long and 1.3 cm broad, and creamy-white, with a rather brittle seed coat. The embryo is small and embedded in an oily endosperm. There are about 1400 seeds per kilogram.

Seed storage

The seed is recalcitrant and should be packed in small quantities (less than 5 kg) in cotton bags. The seeds do not tolerate desiccation below 20% moisture content, and should not be stored at freezing temperatures; they should be sown within six weeks after collection.

Seed presowing treatment

The seed does not need pretreatment.

Seed germination

Germination is hypogeal (Figure 156). It commences with the emergence of the thick, whitish radicle at the scar end. The cotyledonary stalks elongate, and between them the epicotyl pushes up and develops into the seedling stem. The cotyledons are left within the seed coat and remain in the germination medium, attached to the seedlings.

Germination is good but sporadic. It reaches 10% after one week and 60% after four months from sowing.

Plant uses

The fruit is edible. The wood is used to make tool handles, and for fuel. The seed provides an oil used by the Barbaig tribe of central Tanzania as a body and hair lotion, and to oil bows and bowstrings. It is also mixed with butter and used in the preparation of traditional skin skirts. A liquid obtained from boiled roots of *Ximenia americana*, *Dichrostachys cinerea* and *Zanthoxylum chalybeum* is drunk to treat chronic gonorrhea.

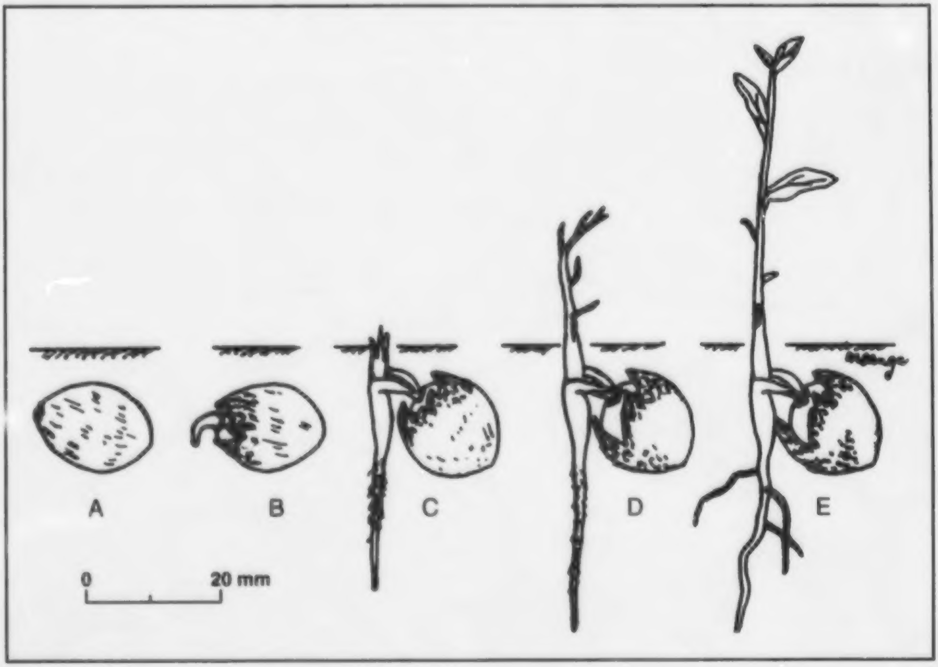


Figure 156. **Stages in seed germination and early development of *Ximenia americana* seedlings.** (**A**) At sowing, (**B**) at 10 days, (**C**) at 14 days, (**D**) at 20 days, (**E**) at 4 weeks after sowing.

Xylocarpus granatum J. König
MELIACEAE

Other names

Mlilana, mkomafi, mtonga, mronga (Kiswahili).

Fruit morphology and seed extraction

The fruit is a large, round capsule, brown when ripe, 15–20 cm in diameter, with a thick, grooved shell which breaks open on falling, to liberate six seeds. At maturity the capsule opens along grooves and seeds can be removed by hand. About 1.5 kg of fruits produce 1 kg of seeds.

Seed morphology

The seed is large, about 8 cm long, angular, and chocolate brown. This is the biggest of all indigenous tree seeds in Tanzania. There are about 12 seeds per kilogram.

Seed storage

The seed is recalcitrant and should be packed in small quantities (less than 5 kg) in cotton bags to provide good ventilation. The seeds cannot tolerate desiccation below 35% moisture content and should not be stored at freezing temperatures. Seeds should be sown within two weeks after collection.

Seed presowing treatment

The seed does not require pretreatment.

Seed germination

Germination is hypogeal (Figure 157). One or more roots appear at the scar point, then many adventitious roots soon differentiate at the base and grow rapidly to form the final root system, which has no definite taproot. The epicotyl pushes its way out between the cotyledonary stalks, and turns into a stout shoot, covered with scale-like leaves. The cotyledons are left within the seed coat, which remains submerged in the germination medium. Some seeds germinate while still in the capsule, or soon after their release.

Germination is very good and uniform if fresh seeds are sown. It reaches 80% after four weeks and 95% after five weeks.

Plant uses

The mahogany-like timber is used for the masts of dhows. Liquid obtained by boiling unripe fruit is drunk as an aphrodisiac. The stem and branches make good firewood and are used for smoking fish.

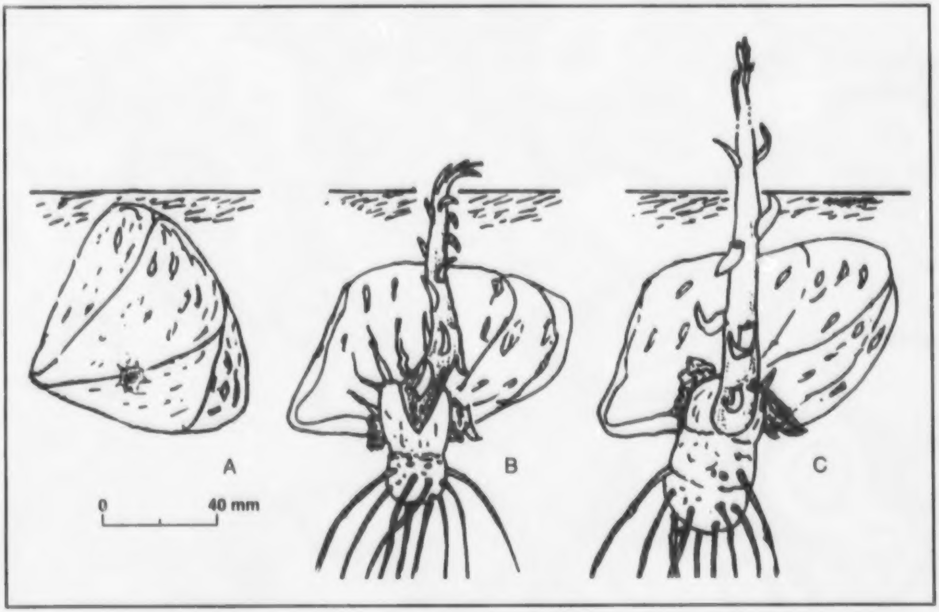


Figure 157. **Stages in seed germination and early development of *Xylocarpus granatum* seedlings.** **(A)** At sowing, **(B)** at 2 weeks, **(C)** at 3 weeks after sowing.

Xymalos monospora (Harv.) Baill.

MONIMIACEAE

Other names

Lemonwood; ikeko (Kipare); ndiri (Kichaga); mdimudimu (Kisambaa); mulilatiro (Kihaya); kinyamasa (Kihehe).

Fruit morphology and seed extraction

The fruit is berry-like, egg-shaped, 1–1.5 cm long, and crowned with a persistent stigma; it is green at first, turning yellow or reddish after ripening. Ripe fruits are picked from trees and the skin and pulp peeled off with a knife. Each fruit contains one seed. About 5 kg of fruits produce 1 kg of seeds.

Seed morphology

The seed is egg-shaped, about 8 mm long and 6 mm broad, soft, creamy-white, with a thin papery seed coat. There are about 3500 seeds per kilogram.

Seed storage

The seed is recalcitrant and should be packed in small quantities (less than 5 kg) in cotton bags or in gunny bags made of sisal or jute. Alternatively they can be kept in wire mesh trays under shade. Both methods provide good ventilation.

The seeds cannot tolerate desiccation below 20% moisture content, and should be stored at room temperature. Seeds should be sown within six weeks after collection.

Seed presowing treatment

The seed does not usually require pretreatment. However, pretreatments such as stratification should be investigated, as the germination period is long. The seed coat is thin and fragile, so would not be expected to play a significant role in dormancy. Seeds should be sown immediately after collection, as a delay of only a few days will cause desiccation and death.

Seed germination

Germination is epigeal (Figure 158). The seed swells slightly and the seed coat ruptures. The radicle emerges through the scar and pushes its way downwards. The hypocotyl elongates, bending greatly, and carries the cotyledons above the germination medium. Later the cotyledons expand and change colour from white to green, while pulling themselves from the seed coat.

Germination is very good, but sporadic and prolonged. It reaches 50% after six weeks and 95% after 10 weeks from sowing.

Plant uses

The wood is suitable for furniture, brush handles, flooring, shoe heels and mouldings. It is also used for making traditional beehives, spoons and food stirrers. The stem is used for hut poles.

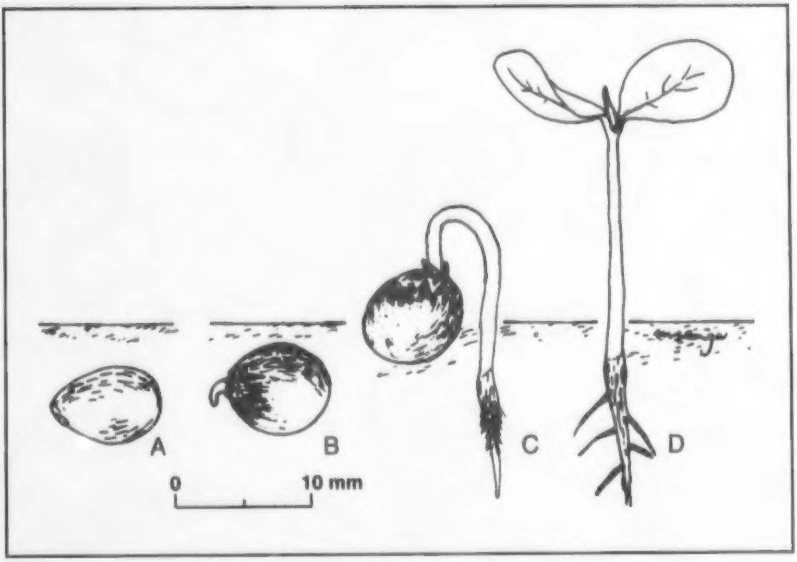


Figure 158. Stages in seed germination and early development of *Xymalos monospora* seedlings. (A) At sowing, **(B)** at 30 days, **(C)** at 40 days, **(D)** at 65 days after sowing.

Ziziphus abyssinica Hochst. ex A. Rich.

RHAMNACEAE

Other names

Jujube; mkunazi (Kiswahili); kagowole (Kinyamwezi); mtanula (Kihehe); mgugunu (Kisukuma).

Fruit morphology and seed extraction

The fruit is a spherical fleshy drupe, smooth, shiny, and about 1.5 cm across; it is green at first, turning yellow when ripe. The fruits are collected from trees or from the ground and the flesh is removed with a knife, or macerated in water and squashed by hand. The seeds are cleaned by washing in water and are dried in the sun.

Seed morphology

The seeds are contained in a hard stone about 1 cm in diameter (Figure 159). When cracked, it splits into two parts along a line. Although each stone usually contains two kernels, many are found empty. There are 450 stones per kilogram; a kilogram of stones may yield 600 seeds, weighing about 80 g.

Seed storage

Seed is orthodox. Well-dried stones can be stored up to a year, after which viability declines gradually.

Seed presowing treatment

The stones should be cracked with a small hammer or a table vice, and seeds should be removed completely (Figure 159). One stone may contain two seeds, both of which may germinate.

Seed germination

Germination is epigeal (Figure 160). The cotyledons enlarge as the seed absorbs water. The radicle protrudes and develops into a taproot. The hypocotyl is very short, while the cotyledonary stalks are very long; both remain partly submerged in the germination medium. The cotyledons expand and emerge above the medium; they remain attached to the seedling for a long time. On exposure to light they become green. At the fifth day after sowing the radicle emerges, and germination is completed in 15 days. Germination is very good and uniform, reaching 50% after 12 days and 80% after 20 days.

Plant uses

The fruit is edible and is sold in markets. The fruit pulp is used for making juices and local beer in some parts of southern Africa. In Malawi a potent distilled alcoholic drink, Kachasu, is made from the fruit. The tree provides firewood, fodder, bee forage, windbreaks and live fencing, and is planted for soil conservation in dry areas.

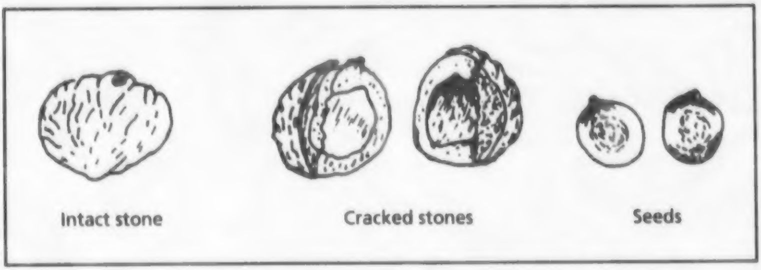
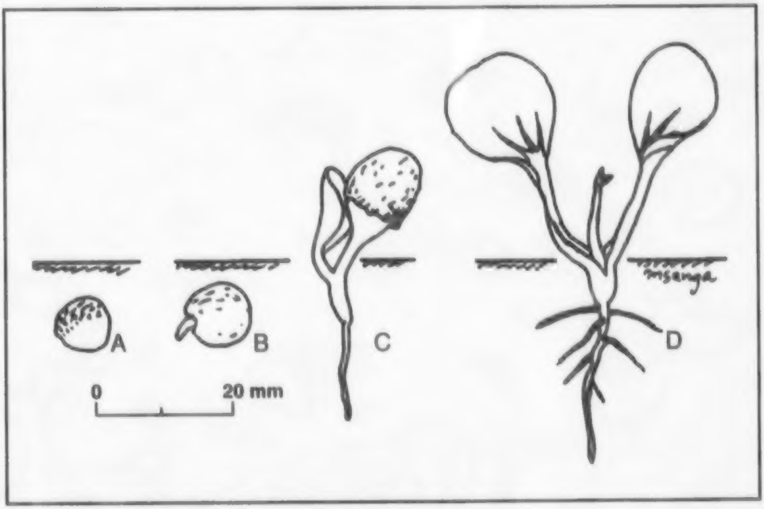

Intact stone
Cracked stones
Seeds

Figure 159. Intact stone, cracked stones and seeds of *Ziziphus abyssinica*.


msenga
A
B
C
D
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20 mm

Figure 160. Stages in seed germination and early development of *Ziziphus abyssinica* seedlings. (A) At sowing, (B) at 5 days, (C) 10 days, (D) 20 days after sowing.

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GLOSSARY

Technical definitions in this glossary are derived, with some modifications, from Bonner (1984), Willan (1985), ISTA (1993), Esau (1977), and USDA (1974).

Abrade: Scrape off or wear away by rubbing; as to abrade a seed coat.

Anaesthetic: Causing lack of sensation.

Anthelmintic: Medicine that kills or expels intestinal worms.

Antidote: An agent which counteracts the effect of a poison.

Antidysenteric: Medicine used to treat diarrhoea.

Areole: Raised area on seed coat (often in the Leguminosae) delineated by a faint line, or pleurogram, running almost parallel with the outline of the seed.

Aril: An appendage covering or partly enclosing the seed, arising from the stalk of the seed.

Berry: A juicy indehiscent fruit having the seeds surrounded by pulp.

Calyx: The outer protective envelope of a flower, consisting of free or united sepals.

Capsule: A dry fruit composed of two or more united parts and either splitting when ripe into pieces called valves, or opening by slits or pores.

Caruncle: An outgrowth near the scar of the seed.

Compound leaf: A leaf comprising several leaflets.

Cotyledon: Modified leaf or leaves of the embryo or seedling, which may contain the stored food reserves of the seed. They are situated at the first node or at the upper end of the juvenile stem (hypocotyl).

Decoction: Liquid obtained by boiling a part of a plant in water.

Dehiscent: Splitting open at maturity to discharge contents.

Dormancy: A state in which a viable seed does not germinate, even in the presence of favourable environmental conditions.

Drupe: A stone-fruit, e.g. fruit of *Maesopsis, Vitex, Sclerocarya, Parinari.*

Embryo: The rudimentary plant enclosed in a seed, generally comprising the radicle, from which the root will develop; the stem-like axis, or hypocotyl; the cotyledons, or seed-leaves; and the epicotyl or plumule, from which the stem and true leaves develop.

Empty seed: A seed which does not contain all tissue essential for germination.

Endemic: Found only in a specific, frequently restricted, locality; e.g. an endemic species.

Endocarp: The innermost layer of the fruit (pericarp).

Endosperm: Nutrient storage tissue surrounding the embryo in some seeds.

Endospermic: Term describing a seed containing endosperm.

Epicotyl: The shoot of the embryo or seedling above the cotyledon(s), consisting of an axis and leaf primordia.

Epigastric: Pertaining to the stomach.

Epigeal germination: A form of germination in which the cotyledon(s) are forced above the surface of the germination medium by the growing hypocotyl.

Filled seed: A seed containing all tissue essential for germination.

Funicle: The stalk of an ovule or seed.

Germination: Resumption of active growth in an embryo, which results in its emergence from the seed and development of those structures essential to plant development.

Hard seeds: Seeds which remain hard and ungerminated at the end of a prescribed test period because they have not absorbed water, due to an impermeable seed coat.

Hilum: The scar left on a seed by the detached seed stalk.

Hypocotyl: Part of embryo or seedling between the cotyledon(s) and the radicle.

Hypogeal germination: Germination in which the cotyledons remain below the surface of the germination medium.

Imbibition: The mechanism of initial water uptake by seeds.

Infusion: Extract obtained by soaking part of a plant in liquid, often water.

Intermediate germination: Germination exhibiting aspects of both epigeal and hypogeal germination; cotyledons and seed coat may remain partly submerged in the germination medium.

Kernel: Softer part within hard shell of nut or stone-fruit, comprising embryo or storage tissue.

Morphology: The study of form and structure (e.g. of fruits and seeds).

Mucilaginous: Viscous; jelly-like, slimy or sticky.

Non-endospermic: Term describing a seed not containing endosperm.

Orthodox: Term used to describe species of which the seeds can be dried down to a low moisture content (around 5%) and successfully stored at low or sub-freezing temperatures for long periods.

Pinna: The primary division of a compound leaf.

Pod: A dry fruit formed of a single carpel, e.g. fruit of legumes.

Pollard: To cut all branches above a certain height, in the upper part of a tree.

Pretreatment: Any kind of treatment applied to seeds to overcome dormancy and hasten germination.

Purgative: Medicine for hastening elimination of waste matter from the body.

Radicle: The embryonic root. Forms the basal continuation of the hypocotyl in an embryo.

Recalcitrant: Term used to describe species of which the seeds cannot survive drying below a relatively high moisture content, and cannot be successfully stored for long periods, or at low or freezing temperatures.

Scarification: Disruption of seed coats, usually by mechanical abrasion or by brief chemical treatment, to increase their permeability to water and gases, or to lower their mechanical resistance to seedling emergence.

Seed: A matured ovule which contains an embryo and nutritive tissue and is enclosed in protective layers or tissue (seed coat).

Seed coat: Protective outer layer of a seed. When two coats are present, the thick outer coat is the testa and the thin inner coat is the tegmen.

Sound seed: A seed which is viable and contains, in viable condition, all tissues necessary for germination.

Stratification: The practice of placing seeds in or on a moist medium, to overcome dormancy.

Stipule: Small leaf-like appendage to a leaf; usually found at the base of the leaf-stem.

Tegmen: The inner seed coat; usually thin and delicate.

Testa: The outer coat of a seed, usually hard or tough.

Viable: The state of being alive; may be capable of germination, subsequent growth and development into a normal seedling.

APPENDIX 1

SEED WEIGHTS, PRETREATMENTS, GERMINATION, AND STORAGE: CHARACTERISTICS AND REQUIREMENTS BY SPECIES

Species	Number of seeds/kg	Pre-treatment for bulk quantities[a]	Germination (%)	Germination periods (days)			Seed type[b]	Longevity in storage (years)[c]
				Imbibition (I)	Total (T)	Differential (T–I)		
Acacia drepanolobium	26 000	Cold water 6 hours	95	6	10	4	O	3
Acacia nilotica	6 000	Boiling or hot water	74	10	20	10	O	5
Acacia polyacantha	14 000	Hot water	77	12	20	8	O	3
Acacia senegal	10 000	Cold water 6 hours	95	15	20	5	O	3
Acacia sieberiana	4 000	Boiling or hot water	65	14	25	11	O	5
Acacia tanganyikensis	6 000	Hot water	90	7	10	3	O	3
Acacia tortilis	18 000	Boiling or hot water	90	7	12	5	O	5
Acacia xanthophloea	30 000	Hot water	90	7	12	5	O	3
Acokanthera schimperi	6 000	Not required	80	12	20	8	R	2 mo
Adansonia digitata	2 500	Hot water	65	28	84	56	O	4
Afzelia quanzensis	485	Remove aril; abrasion	90	20	25	5	O	5
Agelaea pentagyna	2 000	Remove aril	100	15	20	5	R	1 mo
Albizia anthelmintica	7 500	Not required	80	8	10	2	O	2
Albizia harveyi	9 000	Cold water 12 hours	65	12	21	9	O	2
Albizia lebbeck	7 500	Boiling or hot water	65	12	22	10	O	2
Albizia petersiana	8 000	Cold water 6 hours	65	14	21	7	O	3
Albizia schimperiana	10 000	Hot water	70	20	30	10	O	2
Albizia tanganyicensis	7 200	Cold water 12 hours	80	7	10	3	O	2
Allanblackia stuhlmannii	100	Remove aril	80	90	180	90	R	1 mo
Anthocleista grandiflora	400 000	Not required	60	14	28	14	I	1
Antiaris toxicaria	1 500	Not required	80	15	20	5	R	1.5 mo
Azanza garckeana	4 000	Not required	80	15	20	5	I	6 mo
Balanites aegyptiaca	800	Soak in tap water 12 hours	70	14	28	14	O	3
Baphia kirkii	1 000	Not required	80	15	30	15	O	3
Bauhinia petersiana	1 500	Cold water 12 hours	70	21	35	14	O	6 mo
Bauhinia thonningii	7 000	Hot water	80	12	16	4	O	5
Beilschmiedia kweo	45	Not required	70	60	90	30	R	2 mo
Berchemia discolor	10 000	Cold water 12 hours	65	42	70	28	O	2
Bersama abyssinica	1 200	Remove aril	70	49	70	21	R	1 mo
Bombax rhodognaphalon	3 000	Not required	90	10	15	5	I	3 mo

Boscia salicifolia	4 000	Not required	90	10	15	5	O	1 mo
Brachystegia spiciformis	2 000	Not required	98	12	20	8	O	1
Brackenridgea zanguebarica	4 000	Not known	45	70	140	70	O	1
Bridelia micrantha	19 500	Not required	100	25	30	5	R	2 wk
Brucea antidysenterica	10 000	Remove endocarp	100	20	27	7	I	6 mo
Burkea africana	14 000	Hot water	50	10	25	15	O	3
Bussea massaiensis	2 000	Not required	100	7	10	3	O	2
Caesalpinia trothae	2 000	Not required	95	10	15	5	O	2
Calpurnia aurea	25 000	Hot water	72	15	20	5	O	3
Catunaregam spinosa	40 000	Not required	100	15	20	5	I	3 mo
Cephalosphaera usambarensis	35	Not required	97	42	49	7	R	6 wk
Clerodendrum cephalanthum	10 000	Remove endocarp	60	15	25	10	O	4
Clutia abyssinica	120 000	Not required	10	15	25	10	I	4 mo
Combretum zeyheri	1 000	Remove endocarp	45	15	25	10	I	2 mo
Cordia africana	5 000	Cold water 3 days	70	14	35	21	O	2
Cordyla africana	100	Not required	90	28	35	7	R	1 mo
Cordyla densiflora	90	Not required	80	21	28	7	R	1 mo
Crotalaria grandibracteata	40 000	Cold water 6 hours	90	7	14	7	O	2
Croton macrostachys	25 000	Not required	40	14	28	14	I	6 mo
Croton megalocarpus	1 000	Not required	75	15	30	15	I	6 mo
Dalbergia melanoxylon	16 000 pieces	Cold water 6 hours	60	20	40	20	O	1
Deinbollia borbonica	3 500	Not required	97	12	16	4	I	1
Delonix elata	3 700	Hot water	90	10	15	5	O	3
Dichrostachys cinerea	18 000	Boiling or hot water	90	7	15	8	O	5
Diospyros kirkii	500	Cold water 12 hours	70	21	42	21	O	3
Diospyros mespiliformis	2 000	Cold water 12 hours	90	21	42	21	O	3
Diospyros zombensis	500	Cold water 12 hours	55	21	42	21	O	3
Dodonaea viscosa	90 000	Cold water 12 hours	70	14	21	7	O	3
Ekebergia capensis	3 000	Not known	60	28	42	14	R	1 mo
Entandrophragma bussei	1 500	Not known	70	21	28	7	I	6 mo
Entandrophragma excelsum	1 200	Not required	80	28	42	14	I	6 mo
Erythrina abyssinica	3 500	Hot water (75°C)	45	12	24	12	O	4

Species	Number of seeds/kg	Pre-treatment for bulk quantities[a]	Germination (%)	Germination periods (days)			Seed type[b]	Longevity in storage (years)[c]
				Imbibition (I)	Total (T)	Differential (T–I)		
Erythrina burttii	2 500	Hot water (75°C)	60	7	14	7	O	3
Excoecaria bussei	1 800	Not required	100	10	20	10	I	6 mo
Faidherbia albida	8 700	Boiling or hot water	95	5	14	9	O	3
Ficus sur	900 000	Not required	95	14	21	7	I	1
Garcinia livingstonei	150	Not required	80	35	49	14	R	6 wk
Gardenia ternifolia	43 000	Not required	85	28	42	14	I	1
Hagenia abyssinica	400 000	Not required	90	15	20	5	I	6 mo
Jatropha curcas	1 700	Not required	95	10	20	10	I	6 mo
Julbernardia globiflora	1 800	Cold water 6 hours	98	10	15	5	O	1
Juniperus procera	45 000	Warm, cold stratification	50	30	42	12	O	1
Khaya anthotheca	4 000	Not required	90	7	21	14	I	1
Kigelia africana	5 000	Not required	95	15	20	5	I	2 mo
Lannea schweinfurthii	40 000	Not required	30	14	28	14	R	2 wk
Leptonychia usambarensis	15 000	Not required	40	70	77	7	I	2 mo
Lupinus princei	12 000	Not required	75	21	42	21	O	2
Maesopsis eminii	550	Cold water 3 days	65	49	98	49	O	2
Manilkara obovata	3 500	Not required	95	28	42	14	O	2
Markhamia lutea	75 000	Not required	50	15	20	5	O	2
Milicia excelsa	400 000	Not required	60	14	28	14	I	1
Millettia dura	12 000	Cold water 12 hours	50	10	24	14	O	2
Mundulea sericea	80 000	Cold water 12 hours	75	12	25	13	O	1
Newtonia buchananii	8 000	Not required	75	20	30	10	O	1
Ocotea usambarensis	20 000	Hydrogen peroxide	60	21	49	28	R	1.5 mo
Opuntia vulgaris	40 000	Not required	80	21	35	14	O	1
Osyris lanceolata	10 000	Not known	53	42	56	14	I	1

Oxystigma msoo	100	Not required	50	15	25	10	R	6 mo
Parinari curatellifolia	350	Cold water 3 days	20	35	90	55	O	4
Podocarpus usambarensis	210	Remove seed coat	60	42	63	21	O	1
Pterocarpus angolensis	5 700	Cold water 6 hours	70	14	21	7	O	3
Pterocarpus tinctorius	4 700	Not required	80	14	21	7	O	2
Pterygota mildbraedii	1 000	Not required	25	28	49	21	I	6 mo
Pyrenacantha malvifolia	2 000	Not required	100	15	20	5	R	2 mo
Sclerocarya birrea	500	Remove windows	85	7	14	7	O	4
Senna didymobotrya	28 000	Hot water	80	14	21	7	O	3
Sorindeia madagascariensis	2 000	Not required	80	14	21	7	R	1 mo
Spathodea campanulata	200 000	Not required	40	15	25	10	O	1
Sterculia africana	16 000	Not required	40	8	15	7	I	1
Sterculia appendiculata	13 000	Not required	80	14	21	7	I	1
Sterculia quinqueloba	25 000	Not required	43	14	21	7	R	2 mo
Strychnos cocculoides	1 800	Wash seed	75	28	56	28	I	6 mo
Swartzia madagascariensis	9 500	Hot water	80	20	25	5	O	3
Syzygium cordatum	450	Not required	90	28	35	7	R	1 mo
Syzygium guineense	450	Not required	90	28	35	7	R	1 mo
Tamarindus indica	2 600	Cold water 6 hours	90	28	35	7	O	4
Tephrosia interrupta	90 000	Hot water	80	10	21	11	O	2
Tephrosia vogelii	80 000	Hot water	75	12	25	13	O	1
Terminalia sericea	1 700	Cold water 6 hours	60	10	30	20	O	3
Treculia africana	4 300	Not required	100	10	15	5	R	1 mo
Trichilia emetica	1 300	Remove aril	95	10	20	10	R	1 mo
Turraea robusta	25 000	Remove aril	20	20	35	15	R	1.5 mo
Uapaca kirkiana	2 500	Not required	70	28	42	14	R	2 wk
Vangueria infausta	500	Split seed coat	70	23	40	17	O	2
Vitex doniana	2 000	Cold water 24 hours	60	35	56	21	O	2
Vitex keniensis	2 500	Cold water 24 hours	60	28	49	21	O	2
Voacanga africana	10 000	Not required	90	28	49	21	I	1
Warburgia salutaris	24 000	Not known	95	28	49	21	R	2 mo

Species	Number of seeds/kg	Pre-treatment for bulk quantities[a]	Germination (%)	Germination periods (days)			Seed type[b]	Longevity in storage (years)[c]
				Imbibition (I)	Total (T)	Differential (T–I)		
Xeroderris stuhlmannii	2 300	Not required	95	7	12	5	O	2
Ximenia americana	1 400	Not required	60	7	28	21	R	1.5 mo
Xylocarpus granatum	12	Not required	95	28	35	7	R	2 wk
Xymalos monospora	3 500	Not required	95	42	70	28	R	1.5 mo
Ziziphus abyssinica	600	Remove shell	80	12	20	8	O	1

[a] Where pretreatment is not required, germination of some species may be accelerated by soaking seed in cold water for up to six hours (*see* species descriptions).

[b] Seed type: O = orthodox; I = intermediate; and R = recalcitrant.

[c] Longevity may vary from figures given; it is influenced by general conditions, as noted in the introduction, and by conditions detailed separately for each species.

APPENDIX 2

ENGLISH, KISWAHILI AND VERNACULAR NAMES WITH SCIENTIFIC EQUIVALENTS

African blackwood	*Dalbergia melanoxylon*
African bread fruit	*Treculia africana*
African chewing gum	*Azanza garckeana*
African ebony	*Diospyros mespiliformis*
African mahogany	*Khaya anthotheca*
African star chestnut	*Sterculia africana*
Ana tree	*Faidherbia albida*
Apple-ring acacia	*Faidherbia albida*

Baobab	*Adansonia digitata*
Bean mahogany	*Afzelia quanzensis*
Bean-pod tree	*Brachystegia spiciformis*
Bird plum	*Berchemia discolor*
Black galled acacia	*Acacia drepanolobium*
Black plum	*Vitex doniana*
Bloodwood	*Pterocarpus angolensis*
Broad leaved croton	*Croton macrostachys*
Bushishi	*Tamarindus indica*

Cabbage tree	*Anthocleista grandiflora*
Cactus	*Opuntia vulgaris*
Camel’s foot leaf tree	*Bauhinia thonningii*
Chingenye	*Swartzia madagascariensis*

Desert date	*Balanites aegyptiaca*
Dog plum	*Ekebergia capensis*

East African camphorwood	*Ocotea usambarensis*
East African greenheart	*Warburgia salutaris*
East African juniper	*Juniperus procera*
East African laburnum	*Calpurnia aurea*
East African pencil cedar	*Juniperus procera*
East African sandalwood	*Osyris lanceolata*
Ezeya	*Treculia africana*

Falcon’s claw acacia	*Acacia polyacantha*
False mvule	*Antiaris toxicaria*
Fever tree	*Acacia xanthophloea*
Fever-berry croton	*Croton megalocarpus*
Fig tree	*Ficus sur*
Flame of the forest	*Spathodea campanulata*
Furahishamkundu	*Opuntia vulgaris*

Geninyet	*Gardenia ternifolia*
Gum arabic	*Acacia senegal*

Hopbush	*Dodonaea viscosa*

Ichekechi	*Crotalaria grandibracteata*
Ifurufuru	*Croton macrostachys*
Iharage la nkoma	*Lupinus princei*
Ikeko	*Xymalos monospora*
Ikochokocho	*Bersama abyssinica*
Ing’andiri	*Pyrenacantha malvifolia*
Ipojo	*Tephrosia interrupta*
Irato	*Anthocleista grandiflora*
Isenu	*Senna didymobotrya*
Isusu	*Excoecaria bussei*
Ithibati	*Brucea antidysenterica*

Jujube	*Ziziphus abyssinica*

Kagowole	*Ziziphus abyssinica*
Kapok tree	*Bombax rhodognaphalon*
Kasanda	*Swartzia madagascariensis*
Katongotongo	*Excoecaria bussei*
Kibaazi	*Tephrosia interrupta*
Kibaazi	*Tephrosia vogelii*
Kifabakazi	*Spathodea campanulata*
Kijame	*Acacia nilotica*
Kikonda	*Swartzia madagascariensis*
Kikwata	*Acacia senegal*
Kilazingi	*Clerodendrum cephalanthum*
Kinyamasa	*Xymalos monospora*
Kiumang’ombe	*Catunaregam spinosa*
Kivarivari	*Gardenia ternifolia*
Kizulu	*Osyris lanceolata*

Laiyangaloni	*Calpurnia aurea*
Lantern tree	*Dichrostachys cinerea*

Large fruited combretum	*Combretum zeyheri*
Large leaved cordia	*Cordia africana*
Large leaved sterculia	*Sterculia quinqueloba*
Lemon wood	*Xymalos monospora*
Lengijabe	*Hagenia abyssinica*
Liturunga	*Hagenia abyssinica*
Livindwe	*Acacia polyacantha*
Livuluku	*Croton macrostachys*
Long-podded albizia	*Albizia schimperiana*
Lucky bean	*Afzelia quanzensis*
Mafura	*Trichilia emetica*
Many-stemmed albizia	*Albizia petersiana*
Marula	*Sclerocarya birrea*
Mase	*Ocotea usambarensis*
Maya	*Treculia africana*
Mbachanga	*Cordyla africana*
Mbalamwezi	*Sterculia appendiculata*
Mbamba	*Bersama abyssinica*
Mbangwe	*Trichilia emetica*
Mbapu	*Cordia africana*
Mbasamono	*Bersama abyssinica*
Mbefu	*Bussea massaiensis*
Mbetu	*Bussea massaiensis*
Mbokoboko	*Entandrophragma excelsum*
Mbukwe	*Erythrina burttii*
Mbula	*Parinari curatellifolia*
Mbundi	*Erythrina abyssinica*
Mbungu	*Treculia africana*
Mbura	*Parinari curatellifolia*
Mburuga	*Caesalpinia trothae*
Mbuyu	*Adansonia digitata*
Mbwakambwaka	*Deinbollia borbonica*
Mbwejele	*Sclerocarya birrea*
Mchangoko	*Catunaregam spinosa*
Mchelegembe	*Dichrostachys cinerea*
Mchole	*Leptonychia usambarensis*
Mchungu	*Acokanthera schimperi*
Mdaria	Vangueria infausta
Mdayo	*Turraea robusta*
Mdele	*Warburgia salutaris*
Mdimudimu	*Xymalos monospora*
Mdomboza	*Tephrosia vogelii*
Meru oak	*Vitex keniensis*
Mfausiku	*Delonix elata*
Mfetru	*Bussea massaiensis*
Mfimbo	*Beilschmiedia kweo*
Mfuare	*Ekebergia capensis*
Mfufu	*Cordia africana*
Mfumbi	*Bauhinia petersiana*
Mfune	*Sterculia appendiculata*
Mfurifuri	*Croton macrostachys*
Mfuru	*Vitex doniana*
Mfuru	*Vitex keniensis*
Mfuruanje	*Albizia schimperiana*
Mfurufuru	*Croton macrostachys*
Mgambo	*Warburgia salutaris*
Mgando	*Burkea africana*
Mgandu	*Berchemia discolor*
Mghara	*Acacia tortilis*
Mgobwali	*Bauhinia petersiana*
Mgoda	*Sorindeia madagascariensis*
Mgolimasi	*Trichilia emetica*
Mgude	*Bombax rhodognaphalon*
Mgude	*Sterculia appendiculata*
Mgugunu	*Ziziphus abyssinica*
Mgunga	*Acacia nilotica*
Mgunga	*Acacia polyacantha*
Mgunga	*Acacia tanganyikensis*
Mgunga	*Acacia tortilis*
Mgunga	*Acacia xanthophloea*
Mgunga	*Faidherbia albida*
Mguruka	*Pterygoia mildbraedii*
Mguwa	*Sterculia quinqueloba*
Mgwata	*Acacia senegal*
Mgwata	*Cordyla africana*
Mgweja meno	*Turraea robusta*
Mhafa	*Millettia dura*
Mhangala	*Julbernardia globiflora*
Mhavi	*Millettia dura*
Mhende	*Clutia abyssinica*
Mhija	*Warburgia salutaris*
Mhozya	*Sterculia africana*
Misele	*Delonix elata*
Mjafari	*Erythrina abyssinica*
Mjangengo	*Trichilia emetica*
Mjaya	*Treculia africana*
Mjohoro mpweke	*Diospyros mespiliformis*
Mjongolo	*Diospyros mespiliformis*
Mjongolo	*Diospyros zombensis*
Mkaa	*Warburgia salutaris*
Mkababu	*Faidherbia albida*
Mkaburi	*Jatropha curcas*
Mkala	*Tephrosia vogelii*
Mkala wa nkoma	*Tephrosia interrupta*
Mkalakore	*Bridelia micrantha*
Mkambabu	*Faidherbia albida*
Mkangazi	*Khaya anthotheca*

Mkani	*Allanblackia stuhlmannii*
Mkanye	*Allanblackia stuhlmannii*
Mkarakanga	*Baphia kirkii*
Mkarambaki	*Warburgia salutaris*
Mkaranga mti	*Bombax rhodognaphalon*
Mkarati	*Burkea africana*
Mkenge	*Albizia harveyi*
Mkenge	*Albizia schimperiana*
Mkengewa	*Acacia polyacantha*
Mkimbo	*Allanblackia stuhlmannii*
Mkingu	*Albizia lebbeck*
Mkingu	*Albizia tanganyicensis*
Mkirika	*Turraea robusta*
Mkiryo	*Pterocarpus tinctorius*
Mkizingo	*Balanites aegyptiaca*
Mkofi	*Newtonia buchananii*
Mkofi	*Opuntia vulgaris*
Mkokola	*Afzelia quanzensis*
Mkola	*Afzelia quanzensis*
Mkomafi	*Xylocarpus granatum*
Mkomba	*Antiaris toxicaria*
Mkomba	*Bauhinia petersiana*
Mkonga	*Balanites aegyptiaca*
Mkongo	*Afzelia quanzensis*
Mkongoni	*Trichilia emetica*
Mkora	*Afzelia quanzensis*
Mkoromaji	*Trichilia emetica*
Mkufi	*Newtonia buchananii*
Mkukuku	*Acacia polyacantha*
Mkulagembe	*Dichrostachys cinerea*
Mkulo	*Ocotea usambarensis*
Mkuluka	*Boscia salicifolia*
Mkunazi	*Ziziphus abyssinica*
Mkunde	*Antiaris toxicaria*
Mkundi	*Pterygota mildbraedii*
Mkungugu	*Acacia tortilis*
Mkungulanga	*Sterculia quinqueloba*
Mkunguma	*Sorindeia madagascariensis*
Mkungwina	*Trichilia emetica*
Mkuni	*Berchemia discolor*
Mkuruka	*Boscia salicifolia*
Mkuruti	*Baphia kirkii*
Mkusu	*Uapaca kirkiana*
Mkutani	*Albizia anthelmintica*
Mkuyu	*Ficus sur*
Mkwaia	*Mundulea sericea*
Mkwaju	*Tamarindus indica*
Mkwakamwaka	*Deinbollia borbonica*
Mkwata	*Cordyla africana*
Mkwata	*Cordyla densiflora*
Mkwazu	*Tamarindus indica*
Mkwe	*Brachystegia spiciformis*
Mkwelandege	*Sterculia quinqueloba*
Mkweo	*Beilschmiedia kweo*
Mkweranyani	*Sterculia quinqueloba*
Mkwingwina	*Sorindeia madagascariensis*
Mlaka	*Acacia sieberiana*
Mlalai	*Croton megalocarpus*
Mlama	*Combretum zeyheri*
Mlama	*Syzygium cordatum*
Mlama	*Syzygium guineense*
Mlande	*Croton megalocarpus*
Mlangau	*Calpurnia aurea*
Mlele	*Delonix elata*
Mlembelembe	*Voacanga africana*
Mliandege	*Turraea robusta*
Mlifu	*Warburgia salutaris*
Mlilana	*Xylocarpus granatum*
Mlungu	*Erythrina abyssinica*
Mluze	*Sterculia africana*
Mmarie	*Bridelia micrantha*
Mmasai	*Syzygium guineense*
Mnago	*Berchemia discolor*
Mng'ong'o	*Sclerocarya birrea*
Mninga	*Pterocarpus angolensis*
Mnoga	*Bauhinia petersiana*
Mntundutwa	*Ximenia americana*
Mnumbulu	*Diospyros kirkii*
Mnumbulu	*Manilkara obovata*
Mnyahumbu	*Berchemia discolor*
Mnyanga	*Jatropha curcas*
Mnyasa	*Newtonia buchananii*
Mnyinga	*Xeroderris stuhlmannii*
Mnywewe	*Strychnos cocculoides*
Mondogondo	*Xeroderris stuhlmannii*
Monkey chair	*Pyrenacantha malvifolia*
Monkey orange	*Strychnos cocculoides*
Monko	*Ekebergia capensis*
Motovo	*Azanza garckeana*
Mpekeso	*Garcinia livingstonei*
Mpera mwitu	*Strychnos cocculoides*
Mpilipili	*Sorindeia madagascariensis*
Mpingi	*Ximenia americana*
Mpingo	*Dalbergia melanoxylon*
Mpini	*Terminalia sericea*
Mpiripiri	*Sorindeia madagascariensis*
Mpojoro	*Albizia anthelmintica*
Mpongolo	*Catunaregam spinosa*

Mpugusi	*Milicia excelsa*
Mpululu	*Terminalia sericea*
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Mramba	*Adansonia digitata*
Mranguwe	*Bersama abyssinica*
Mratine	*Kigelia africana*
Mreraiambo	*Albizia schimperiana*
Mrie	*Milicia excelsa*
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Mrindawa	*Bersama abyssinica*
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Mririgwi	*Albizia schimperiana*
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Mrosirose	*Hagenia abyssinica*
Mrungurya	*Cordia africana*
Msacha	*Turraea robusta*
Msada	*Vangueria infausta*
Msaghwa	*Kigelia africana*
Msambu	*Allanblackia stuhlmannii*
Msandali	*Osyris lanceolata*
Msangala	*Burkea africana*
Msani	*Allanblackia stuhlmannii*
Msantu	*Ximenia americana*
Msaponi	*Bauhinia thonningii*
Msasao	*Acacia nilotica*
Msawola	*Parinari curatellifolia*
Msayu	*Lannea schweinfurthii*
Mse mwanamke	*Podocarpus usambarensis*
Mseele	*Delonix elata*
Msenefu	*Croton megalocarpus*
Mseri	*Ocotea usambarensis*
Mseseve	*Pterocarpus angolensis*
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Mshashita	*Newtonia buchananii*
Mshihwi	*Syzygium cordatum*
Mshihwi	*Syzygium guineense*
Mshunduzi	*Croton macrostachys*
Mshunga	*Podocarpus usambarensis*
Mshunguti	*Acokanthera schimperi*
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Mtanda	*Markhamia lutea*
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Mtanula	*Ziziphus abyssinica*
Mtarakwa	*Juniperus procera*
Mtimaji	*Trichilia emetica*
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Mtondoo	*Khaya anthotheca*
Mtondoro	*Julbernardia globiflora*
Mtondoro	*Khaya anthotheca*
Mtonga	*Strychnos cocculoides*
Mtonga	*Xylocarpus granatum*
Mtowo	*Azanza garckeana*
Mtoyo	*Azanza garckeana*
Mtulankondo	*Gardenia ternifolia*
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Muhumula	*Maesopsis eminii*
Muhunga	*Acacia senegal*
Mukisha	*Kigelia africana*
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Mulilatiro	*Xymalos monospora*
Mumbu	*Lannea schweinfurthii*

Mumenge	*Manilkara obovata*
Mumilwa	*Strychnos cocculoides*
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Mzasa	*Acacia senegal*
Mzejezeje	*Excoecaria bussei*
Mzengute	*Kigelia africana*
Mzongozongo	*Crotalaria grandibracteata*
Mzuli	*Milicia excelsa*
Mzunguzungu	*Bauhinia petersiana*
Mzutwe	*Dodonaea viscosa*
Mzuu	*Osyris lanceolata*
Namkanza	*Agelaea pentagyna*
Ndawiro	*Vangueria infausta*
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